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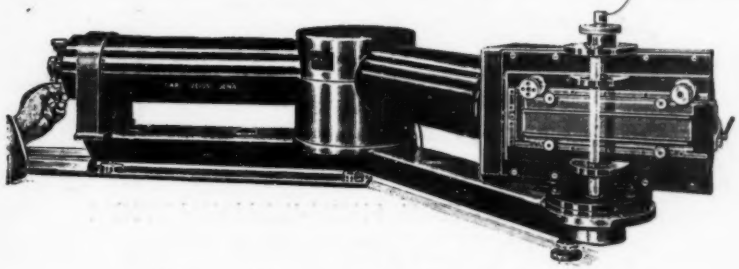

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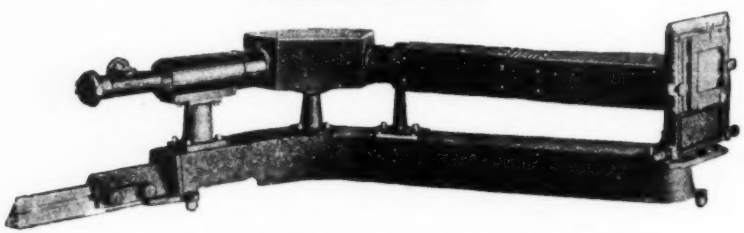

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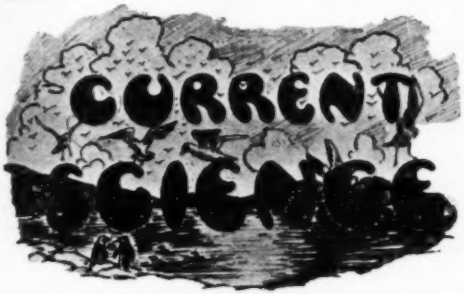

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A Scheme of Broadcast Development for India.

ELSEWHERE in this issue of *Current Science* appears an article on the development of nation-wide radio broadcasting in India to serve as a most valuable tool for national reconstruction on the only possible basis of the renaissance and reconstruction of the village and village life. An examination of the development and present status of broadcasting in such typical countries as France, Germany, Great Britain and Russia in Europe, Canada and the United States in Northern America, and China and India in Asia, leads to the irresistible conclusion that the fundamental cause of the deplorable absence of any progress in India is the apathy and the lack of appreciation by the public and the governments in India of the value and potentialities of broadcasting as a matchless universal propagandist instrument for the promotion of the welfare and happiness of the community and for safeguarding its interests.

The reasons usually put forward for the present pitiably backward condition are unconvincing and really not correct. It is said that the contributory factors are the size of India and its huge population, the pronounced racial, linguistic and religious divisions, the enormous disparity in cultural development between the various sections of the people and chronic poverty and mass illiteracy. But these are not peculiar to India alone; each and every one of them has been and continues to be a striking characteristic of Russia and Russian life. Yet these undoubtedly serious difficulties and disadvantages did not prevent the builders of modern Russia not only from putting Russia on the radio map of the world, but achieving for it a position in the front rank in the radio world in the short space of some half a dozen years. Nor is it correct to say that the severe political unrest and the economic troubles of recent years have stood in the way of Indian radio development. Many other countries, notably, Austria, Germany, Italy and Russia have passed through or are still in the midst of acute political and social turmoil and severe economic distress. Yet they are noted for extensive broadcast development. Even Mexico and China are ahead of India in this respect. Further, it is not clear if

the conduct of the broadcast service from the Bombay and Calcutta stations and their programme composition are based on any well-defined policy with a clear understanding of the main objectives. There is none so poor in the world as India in the matter of broadcasting.

But the budget allotment of 20 lakhs of rupees for broadcasting by the Government of India, their decision to put up a 25 kw transmitter at Delhi and the highly commendable procedure of the Government of Madras in putting forward a worthwhile scheme for the whole presidency after detailed examination of the question by a competent radio engineer, appear to indicate that India has started on the road towards having a satisfactory system. The question arises if behind these there is a well-considered comprehensive plan of development for the whole country in regard to (*a*) organisation, finance and programme policy; (*b*) number and powers of stations and their location; (*c*) the interconnecting wire network; (*d*) receiver distribution; (*e*) manufacture in India of the necessary apparatus; (*f*) development and research in regard to all matters of technique, materials, apparatus and operation; (*g*) the training and recruitment of the necessary personnel of all grades; (*h*) relations with the press, the state departments and foreign broadcast administrations; (*i*) the important question of television and allied matters. A *laissez-faire* policy will be thoroughly wasteful in men, money and effort, besides causing confusion and inequitable and non-uniform development in the country. Any worthwhile development plan has to be based on a thorough examination and critical study of the world situation in broadcasting in all its aspects. And that can be done only by sending out a competent and fully authorised commission of inquiry as advocated at the end of the article. Will the Government act on the suggestion?

Even a brief consideration of the question of broadcasting *on a nation-wide basis* shows that low powers and short wavelengths for transmitters are out of question. There is really no satisfactory alternative to high power and medium wave policy, if the whole area of the country should be brought under adequate and reliable broadcast coverage as determined by daylight reception on an average type of receiver so as to be free from atmospheric disturbances at all parts of the year. Short wavelengths are suitable for long distance reception during limited parts of the day and have entertainment value only with well-designed and rather expensive receiving apparatus.

The transmitting system as visualised in the article is an essentially conservative estimate of requirements. It will probably be found that the number of stations in each category may have to be doubled; the individual powers, particularly of the regional transmitters, may have to be increased by 50 per cent. A receiver per cent. of the population is an under-estimate but is a satisfactory objective to start with.

Community ownership of receivers and community listening were first started in Russia; in countries of high development such as Great Britain, Germany and the United States, this practice is a feature of schools and clubs of all sorts. There is no suitable alternative to this in India, at least for the present.

In regard to the organisations of broadcasting, the article is most emphatic on four basic requirements: (*a*) to retain the unreserved and whole-hearted trust and confidence of the people, the organisation should be completely above the slightest trace of suspicion of allegiance to party and sectional interests of any type; (*b*) the organisation should be an unqualified national monopoly, financed exclusively by the licence fee and public funds and existing solely for the education, enlightenment and entertainment of the community; private commerce should be rigidly excluded from any voice or control on policy or day-to-day conduct of broadcasting; (*c*) the organisation should be such as to ensure uniform broadcast facilities throughout the land and the maintenance of the highest standards of excellence in apparatus, methods and operation; and (*d*) each region should have and exercise the utmost possible freedom in all programme matters.

Organisation as a government department or as private commercial enterprise is both impracticable and intolerable. A highly centralised system such as the British Broadcasting Corporation which has made Great Britain so pre-eminent in broadcasting is wholly unworkable. A non-profit making autonomous public utility organisation with complete centralisation of all technical services and as complete decentralisation in all programme matters and of the type advocated in the article is the only solution.

It goes without saying that advertisement by radio should not even be thought of.

Everywhere and at all stages, the success or failure of a broadcasting system depends on the underlying programme policy and daily programme composition. The only criterion is entertainment and educative value as determined by variety, balance, utility and wide appeal to every section of the community in regard to age, sex, occupation and linguistic and racial grouping. Monotony, stiffness and heavy seriousness kill broadcasting outright. It is futile and shortsighted to design and put up receivers tuned to the local station. That is the finest way to create suspicion and repel the listener. Foreign station listening should be encouraged; it is of some educative value occasionally to hear completely unintelligible music and talk and the sounds of strange voices and instruments far away. And in any case, it is far sounder to make the daily programme so rich, varied, interesting and instructive and of such high entertainment value, that the rural listener, of his own accord, prefers it to others.

Of vital importance to broadcasting and the radio industry in India are the questions of the manufacture of radio apparatus, research and the training of engineers. It is impossible and intolerable to be dependent for them on countries abroad. Distance, cost, natural differences in the conditions of working are all against it. In these matters, private commerce in India and the various educational institutions have a large and fruitful part to play on the basis of a carefully considered definitive formulation of a progressive and far-seeing broadcast development policy.

While the article rightly insists that the broadcasting system has to be built up it has not ventured upon any discussion on the first step to be taken. Such a discussion would have probably been useful though rather premature. But whatever its merits or demerits, it is based upon a careful study of the history and present status of broadcasting abroad and prolonged and earnest consideration of the possibilities and requirements in regard to India and Indian conditions. The article will have more than amply served its purpose if it helps "to create a correct perspective of the vast problem and provoke reasoned discussion on what is inherently a national question" and "to offer some concrete basis for such discussion".

R. E.

The Royal Institute of Science.

WE have received a copy of the second report of the Royal Institute of Science, Bombay, for the period 1926–1934, and we have great pleasure in congratulating the Principal and Professors of this Institution on their unremitting exertions in implementing its declared policy and in achieving great progress in the creation of an atmosphere of research in practically all the departments of science.

The Institute which was founded with the aid of public donations amounting to Rs. 30 lakhs, commenced teaching work in 1920 and was affiliated to the Bombay University for the B.Sc. degree courses in Mathematics, Physics, Chemistry, Botany and Zoology in 1926. In 1933 the then Governor of Bombay handed over the east wing of the Institute to the University to house the new University Department of Chemical Technology. All the scientific departments are well staffed and are fully equipped for the routine teaching work as well as advanced research work. The Library, which is one of the best in the Presidency, contains six thousand volumes of periodicals and five thousand books, but the annual additions to the lending and reference sections of the library, which at the present moment amount to one hundred books and about eighty scientific journals, must naturally depend upon the grants available for the purpose. It seems to us that in view of the important position which the Institute occupies in the academic life of the Presidency and the high purpose which it is so worthily fulfilling, the great industrial magnates of Bombay will increasingly recognise the imperative need of placing the College above financial want; and once they are convinced that research, and not necessity, is the parent of invention as well as of industrial prosperity, their own enlightened self-interest will lead them to create ample endowment fund so as to ensure an adequate annual income to the Institute for post-graduate scholarships and expenditure on research departments.

A great industrial centre like Bombay

should legitimately be interested in the promotion of chemical research and it is gratifying to note that during the period under review, out of a total of 128 original papers published from the Institute, 64 belong to the Department of Chemistry and out of a total of 96 approved theses submitted by research scholars, 52 have been produced by Chemistry students, and similarly there are 52 theses of research in progress in the chemical section of the Institute. The output of investigations from other departments is equally impressive.

The departments of Physical Science in the Institute are the most favoured by the students: there were 71 post-graduate students out of a total of 91 in these sections during 1933–34 and 51 out of a total of 61 students in the same departments in the Senior B.Sc. class in the same period. In 1932–33 the annual cost of educating each student in the Royal Institute of Science was Rs. 608 to which Government contributed Rs. 181. In a country like India where the general public is slow to recognise the advantages of promoting scientific researches, the obligation of Provincial Governments to provide sufficient funds for this purpose becomes greater, especially in view of the fact that almost all the scientific results when used in the technological and industrial concerns, are capable of being taxed. Governments and industrialists stand to gain immediately from scientific work and it should, therefore, receive the greatest encouragement at their hands.

It may be pointed out that the staff cadre of the Institute is capable of improvement. The gap separating the Professor drawing Rs. 1,200 and the immediate next member, an assistant lecturer on Rs. 225 is unnatural and almost unbridgeable. There must be an assistant professor or associate professor in each department on appropriate salary, who could be entrusted with the responsibility of taking charge of the department during the absence of the professor.

The report suffers from one slight defect. On page 23, we read that "sanction has been obtained for an Institute Badge, tablets for academic and athletic rolls of honours have been erected and an Institute Magazine has been started". We should have wished for a fuller information on the social, athletic and other extra-mural activities of the Institute students than is provided by this brief reference.

The report is an interesting document and constitutes a notable record of progress in every department in the Institute whose increasing prosperity and scientific achievements should be an honour to the Principal and Professors and pride to the benevolent public and Government of Bombay.

Nationwide Broadcast Development in India.

By K. Sreenivasan, B.Sc., A.I.I.Sc., A.M.I.E.E., Mem.I.R.E.

ANY worthwhile broadcasting system seeking to serve the mass of the people is inherently a nationwide and national problem. It cannot be considered in the circumscribed sense of a local or even a provincial question. If there is any single problem in which a genuine national outlook is imperative and which demands well-considered nationwide planning, it is radio broadcasting. In technical services, in administration and finance and in programme policy and programme development, every consideration of national economy and social welfare insists upon the whole question being treated as a national problem with the three-fold objective of the instilling of the idea of common Indian citizenship and the promotion of social solidarity, the promotion of public health and of economic prosperity and the spread of general culture and healthy entertainment.

These have to be the aims with reference to the mass of the people living in villages. No organisation and no expense can be anything but waste of wealth and effort when they do not directly and consciously strive after the amelioration of the conditions of life of the rural population which forms the spiritual and economic backbone of the country. A nationwide broadcasting system is justified only when it has for its starting point the villager as citizen, producer and consumer; its fundamental purpose is as the most effective and finest tool in national reconstruction in terms of the rural population living in 650 000 villages.

With these objectives, the organisation of broadcasting has to be on the basis of a

national monopoly deriving its moral support and material strength direct from the listener and always consciously striving to serve his best interests. Conceived thus as an instrument of public service of the highest character, private commerce and vested interests of any kind cannot have the slightest voice in the policy and daily conduct of the service in any shape or form.

BROADCASTING ABROAD.

Before attempting to visualise the magnitude of the broadcasting problem in India, it is essential to survey briefly the status of broadcasting abroad.

In Europe, the organisation of broadcasting is mostly in the form of a national monopoly in the sole interests of the community and of the nation as a political unit. Great Britain offers the best example of a highly centralised type, appropriate to its small size and its homogeneous population. Till the advent of Chancellor Hitler, Germany had a federalised monopolist organisation consistent with its bigger area and its more varied population. In these countries, the periodical subscription from the receiver owner is the most important source of revenue. In Russia, the organisation is under the dictatorial control of the people's central commissariat at Moscow; the State looks after the financing of broadcasting and its development from year to year. In the United States of America, on the other hand, broadcasting is in the hands of private enterprise which raises the necessary revenue by radio publicity of goods and services of private competitive commerce. The Federal Communications Commission, a government body, endeavours to secure equitable development of broadcasting throughout the country and ensure reception free from interference. In India, broadcasting started in 1927 as a private commercial monopoly with the licence fee and radio publicity as the two sources of revenue. When, however, this arrangement collapsed, the State took it over and is now responsible for the conduct of the service from the Bombay and Calcutta stations.

From Table I some idea of the popularity of the service in the different countries can be obtained from an examination of the available broadcast facilities and of the number of receiving sets in each. In Germany, there are 26 medium wave transmitters with a total antenna power of over 800 kw. There are over 6 million receivers for a population of 63 millions. Great Britain, which is about half the size of Germany or about one-twentieth of that of India in area, has 14 transmitting stations with a total antenna power of over 550 kw. The number of receivers for a population of 44 millions stands at the very high figure of over 6·7 millions. In the United States, the absence of any national organisation and an initial well-considered development plan has burdened the country with about 600 transmitters. There are over 18 million receiving sets in the country corresponding to 13·1 receivers per cent. of the population. Recently the country provided itself with a 500 kw. transmitter at Cincinnati.

Russia hardly existed on the map of Europe seven years ago. The difficulties in the path of radio development at that time were at least as great as those of India at present. The country is four times as large as India; the population of about 15 crores consists of some 200 racial groupings speaking over 50 different languages and with a range of cultural development from the most primitive to the most advanced. Political and economic revolution of a most drastic character had left the country completely isolated from the rest of the world and the internal upheaval had not yet shown signs of subsidence. But under the dynamic urge of the gigantic plan of organised and comprehensive national reconstruction, radio broadcasting as the most potent tool of nationwide economic and cultural propaganda developed by leaps and bounds. At present, this vast and varied country has 75 transmitters with a total antenna power of 1 500 kw; one of these is the biggest in Europe with 500 kw in the antenna. For a population of 147 millions, there are at present 3 million receivers. Plans for the extension of broadcast facilities during the next few years include the construction of a 1 000 kw transmitter and the increase in the number of receivers from 3 millions to 20 millions corresponding to 14 receivers for every hundred of the population.

For the world as a whole, it is estimated that there are some 2000 transmitters with a total antenna power of roughly 10 000 kw, spread over the inhabited area of 143·7 million square kilometres, and about 45 million receivers for a population of some 1 800 millions. This gives a world average of 2·25 receivers per cent. of the population.

With a most varied population of 351 millions inhabiting 4·66 million square

kilometres, India has a transmitter at Bombay, one at Calcutta, a small one at Madras and a small short wave transmitter at Calcutta, all employing obsolete apparatus. The total antenna power does not exceed 7 or 8 kw. The number of registered listeners does not exceed 12 000, corresponding to a receiver for every 29 000 persons in the country. The service is burdened with a small army of radio pirates who enjoy illicit listening (Fig. 1).

The programme service lasts for 18 hours a day in the United States, 18 hours in Germany, 13·25 hours in Great Britain and about 11 hours in Russia; Bombay transmits for about six hours a day and Calcutta an hour longer. Madras transmissions last about two hours in the evening.

On the financial side, the investment on transmitting equipment in Europe in 1931 was estimated at about 22·5 crores of rupees while that on receiving apparatus was ten times as great. The annual receiver maintenance charges for the same year were estimated to be about 30·2 crores of rupees while the licence fee realised from the listeners amounted to no less than 18·9 crores of rupees. Electricity consumption for broadcast purposes four years ago stood at about 1 573 million kilowatt-hours.

In the matter of programme service, every broadcast organisation in the progressive countries of Europe and America strenuously endeavours to cater to all worthwhile and ascertainable needs and requirements of every section of the community in respect of age, sex, cultural level, occupation and economic and social stratification. The permeation of the effects of broadcasting are so real, deep and universal that it has become a powerful living social force affecting and reflecting the daily life and thoughts of the community. Broadcasting is at once the mouthpiece of the community and its most powerful and universal educative organisation.

Considered from any standpoint of national interest and social well-being, the service in India is hopelessly poor and inadequate. It may be doubted if it has had well-considered and well-defined objectives and policy. In these days of intense and world-wide moral and intellectual upheaval, involving profound changes in the scale of values of ideas and institutions, broadcasting in India has not till now made the slightest contribution as a propagandist and educational instrument.

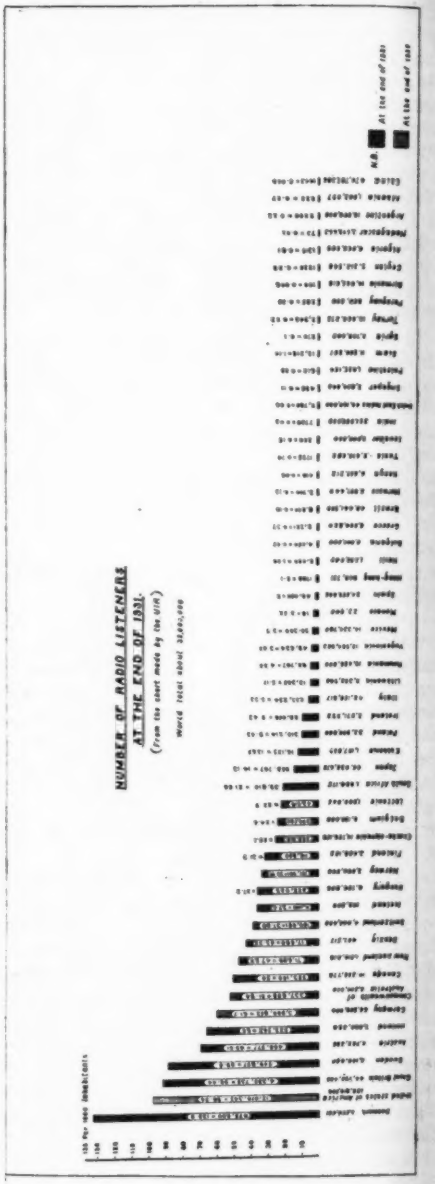
NUMBER OF RADIO LISTENERS
AT THE END OF 1931.
(From the chart made by the U.N.)
World total about 32,000,000
At the end of 1931
At the end of 1930

Fig. 1.

The period of apathy and standstill in matters of broadcast development in India appears to be coming to an end. A year ago, the Government of Madras took the lead in starting a preliminary examination of the question of broadcasting for the

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	COUNTRY	Area in square kilometres	Population in Thousands	Density of population per sq. km.	Total number of medium wave broadcasting stations	Total antenna power in kilowatts	Antenna power of the most powerful station in kilowatts	Antenna power of the weakest station in kilowatts	Antenna power in watts per square kilometre
1	AUSTRALIA ..	7 724 165	6 000	0·78	61				
2	AUSTRIA	83 830	6 600	78·7	7	111	100	0·5	1·33
3	BELGIUM	30 470	8 000	262·5	2	36	18	18	1·18
4	CANADA	9 659 832	9 940	1·04	67	55·5	10	0·005	0·0057
5	CZECHOSLOVAKIA ..	140 400	14 730	104·9	6	184·3	120	2·6	1·31
6	DENMARK ..	42 910	3 560	83·0	3	71	60	1·0	1·65
7	ESTONIA	48 233	1 116	23·1	2	20·5	20	0·5	0·43
8	FINLAND	343 400	3 640	10·6	9	74·15	50	0·25	0·242
9	FRANCE	550 800	41 000	74·4	23	1025	120	0·07	1·86
10	GERMANY ..	470 600	63 000	134·0	26	814·75	120	0·25	1·73
11	GREAT BRITAIN ..	245 100	44 500	181·5	14	560	150	0·12	2·28
12	GREECE	129 450	6 200	47·9	1	1			
13	HOLLAND ..	32 630	8 000	245·2	4	94	60	7·0	2·88
14	HUNGARY ..	92 940	8 700	93·6	6	125·8	120	0·8	1·35
15	IRISH FREE STATE..	69 930	3 000	42·9	3	62·2	60	1·0	0·89
16	ITALY	310 680	43 000	138·4	13	190	100	0·2	0·57
17	JAPAN	675 180	84 000	124·4	26				
18	LATVIA	64 725	2 000	30·9	2	30	15	15·0	0·46
19	LITHUANIA ..	51 780	2 000	38·64					
20	LUXEMBOURG ..	2 589	270	104·3	1	150			5·8
21	MEXICO	1 990 940	16 400	8·24	53				
22	NORWAY	323 800	2 810	86·8	14	67·48	60	0·08	0·21
23	POLAND	388 600	31 000	79·8	8	178·7	120	1·35	0·46
24	ROUMANIA ..	318 100	18 000	56·6	2	12·7	12	0·7	0·04
25	SPAIN	504 600	21 763	43·1	16	16·5	7·6	0·1	0·327
26	SWEDEN	448 500	6 150	13·7	31	121·42	55	0·05	0·27
27	SWITZERLAND ..	41 290	4 100	99·3	6	102·3	60	0·5	2·48
28	TURKEY	1 061 490	14 000	13·2	2	12	7	5·0	0·0113
29	USA	9 682 438	137 000	14·1	585	2000	500		0·21
30	USSR	21 340 000	147 014	6·89	75	1414·4	500	0·5	0·146
31	YUGOSLAVIA ..	243 460	14 000	57·5	3	8·52	5·27	0·75	0·035
32	INDIA	4 673 150	353 000	75·8	2	6	3	3·0	0·0013
	WORLD ..	143 683 000	2 000 000	13·9	About 2 000	About 10 000	500	0·005	(approx.) 0·07

TABLE I.

al nna r in atts	Antenna power of the most powerful station in kilowatts	Antenna power of the weakest station in kilowatts	Antenna power in watts per square kilometre	Number of working hours per day (approx.)	Total number of receiving sets	Number of receivers per 1 000 of the population	Rupee equivalent of licence fee	
					622 674	104	17·3	1. S 2. I
	100	0·5	1·33	15·5	507 479	76·9	10·08	State
	18	18	1·18	10·62	550 165	68·8	25·2	State
·5	10	0·005	0·0057	15·82	548 249	55·2	6·0	Com
·3	120	2·6	1·31		693 694	47·1	10·8	State
	60	1·0	1·65	16.38	568 175	160	8·1	State
·5	20	0·5	0·43		14 758	13·22	12·15	Non-
·15	50	0·25	0·242		121 014	33·3	7·5	Non-
	120	0·07	1·86	14	1 730 243	42·2	6·0	1. S 2. I
·75	120	0·25	1·73	18·15	6 142 921	97·5	17·3	State
	150	0·12	2·28	13·26	6 780 570	152·4	7·5	Non-
					3 318	0·54		
	60	7·0	2·88		648 275	81·03		Publi
·8	120	0·8	1·35		328 179	37·7	15·12	Non-
·2	60	1·0	0·89		45 008	15·0	7·15	State
	100	0·2	0·57		365 000	8·5	12·6	Mono com
					1 822 000	21·7	18·0	Non-
	15	15·0	0·46		50 808	25·4	6·08	State
					17 305	8·65	18·0	State
			5·8					Priva
					800 000	48·8		
·48	60	0·08	0·21	12·12	150 236	53·5	16·2	State
·7	120	1·35	0·46		311 287	10·04	12·15	State
·7	12	0·7	0·04		100 000	5·6	10·8	State
·5	7·6	0·1	0·327		154 662	7·1		Priva
·42	55	0·05	0·27	12·38	666 368	108·3	8·1	State
·3	60	0·5	2·48		355 000	86·6	8·69	State util
	7	5·0	0·0113		5 404	0·39		Mono ente
	500		0·21	17·58	18 500 000	135	0	Priva
·4	500	0·5	0·146	12	2 888 000	19·64	36·0	State
·52	5·27	0·75	0·035		58 896	4·2		
	3	3·0	0·0013	7·18	11 810	0·033	10·0	State
t 0	500	0·005	(approx.) 0·07		45 000 000	22·5		

Rupee equivalent of licence fee	Type of organisation	Sources of revenue	REMARKS	
			No. of transmitting installations to be built	Proposed increase in total antenna power in kilowatts
17·3	1. State. 2. Private commerce.	1. Annual licence fee. 2. Commercial radio publicity.	7	
10·08	State controlled private organisation.	Annual licence fee.		
25·2	State controlled public organisation.	State subvention and licence fee.		
6·0	Commission appointed by Government.	Licence fee; very slight commercial radio publicity.		
10·8	State controlled public utility.	Licence fee.		155
8·1	State ownership and operation.	Licence fee.		
12·15	Non-commercial public monopoly.	Licence fee.		
7·5	Non-commercial public monopoly.	Licence fee.	1	220
6·0	1. State. 2. Private commercial enterprise.	1, Licence fee and state subvention. 2. Commercial radio publicity.		
17·3	State ownership and operation.	Licence fee.		150
7·5	Non-commercial public monopoly.	Licence fee.		100
	....	....	1	50
	Public utility company.	Voluntary subscriptions by individuals and organi-sations.		
15·12	Non-commercial public utility.	Licence fee.		
7·15	State ownership and operation.	1. Customs duties on imported radio goods. 2. Annual licence fee. 3. Commercial radio publicity.		
12·6	Monopoly granted to semi-private company.	1. Tax on radio sales. 2. Licence fee. 3. Commercial radio publicity.	2	250
18·0	Non-commercial public utility.	Licence fee.	18?	500?
6·08	State ownership and operation.	Licence fee.	1	35
18·0	State ownership and operation.	1. Licence fee. 2. State subsidy. 3. Commercial radio publicity.		93
	Private commercial enterprise.	Commercial radio publicity.		
	....	....		
16·2	State ownership and operation.	1. Tax on radio sales. 2. Annual licence fee. 3. Commercial radio publicity.		22
12·15	State controlled private company.	1. Licence fee. 2. Commercial radio publicity.	2	22
10·8	State controlled joint stock company.	1. Licence fee. 2. Commercial radio publicity.	9	330
	Private commercial enterprise.	1. Subvention. 2. Voluntary subscription. 3. Commercial radio publicity.	10	180?
8·1	State ownership and private enterprise.	Licence fee.		90
8·69	State controlled non-commercial public utility.	Licence fee.		75
	Monopoly with private commercial enterprise.	1. Customs duty on imported radio goods. 2. Licence fee. 3. Commercial radio publicity.	1	150
0	Private commercial enterprise.	Commercial radio publicity.		
36·0	State ownership and operation.	Licence fee.	29	1500?
	....	Licence fee.		52
10·0	State ownership and operation.	1. Customs duty on imported radio goods. 2. Licence fee. 3. Commercial radio publicity.		

presidency; indications go to show that the scheme submitted by them to the Central Government is of a character as will assure the presidency, if put into execution, of a thoroughly satisfactory and up-to-date system. Of greater significance is that the Government of India is also active as shown by their decision to put up a 20 kw transmitter at Delhi and the budget allotment of 20 lakhs of rupees. It is not clear, however, if this forms the first step of a well-planned, comprehensive nationwide broadcast development policy.

PROBLEM OF NATIONWIDE BROADCASTING.

With some idea of the status of broadcasting abroad, we can now consider the problem of what constitutes nationwide broadcasting. On the theoretical side, we have to consider (*a*) the number and individual powers of transmitters and their location to secure for the listener throughout the day and all the year round a satisfactory and adequate signal in relation to atmospheric disturbances; (*b*) the necessary high grade telephone network to interlink the different stations for distribution and interchange of programmes; and (*c*) the number of receiving sets to ensure that any one desiring to listen to the radio programme of entertainment and instruction can do so. The organisation should be such as to assure uniformly efficient and economic technical services throughout the land and at the same time guarantee the utmost flexibility and freedom to every region in programme-building within the broad confines of a well-considered and well-understood national policy.

There is the proposal for the installation of small power stations with service areas of 25 or 50 kilometres radius, so that each locality or district can have its own programme and in its own language. In support of this proposal, a representative of a radio firm of Great Britain has been touring the country visiting various governmental authorities. Within the last few weeks, schemes on this basis have been inaugurated in the North-Western Frontier Province and the United Provinces. Satisfactory as it may be in the case of isolated small areas, the proposal is thoroughly unsound, impracticable and unworkable on a nationwide basis. It will involve hundreds of stations, all to be accommodated within a strictly limited band of frequencies. Even with unusual and expensive precautions, regions of interference will be inevitable; it is certain that except in the neighbourhood of transmitters, atmospheric disturbances will ruin reception. Difficulties connected with the availability of suitable microphone talent in each locality and of programme expenditure for such a large number of transmitters cannot be exaggerated. Recorded entertainment and voluntary micropnone talent can never be sustained in quality and adequate in volume to prevent boredom, monotony and heaviness.

More important than any of these is that such a scheme is a standing invitation for the perpetuation and aggravation of the baneful spirit of provincialism and of the numerous sectional interests which tend to disrupt the community into mutually antagonistic fragments. Everything should be designed with the deliberate aim of promoting social harmony and solidarity in common citizenship.

On the other hand, there are those who suggest the erection of a small number, say a dozen, of super power stations located suitably. It will be urged that besides being very economical and efficient in money and effort, such a scheme will assist powerfully the promotion of social harmony.

While there are no difficulties in putting up very high power stations, such a scheme will involve large wipe-out areas round the transmitters, rapid reduction in intensity with distance, etc. Further, it will be impossible to serve the worthwhile and legitimate needs and requirements of the varied population and to preserve and enrich the varied culture of the country.

From every point of view, the most satisfactory arrangement appears to be to develop broadcasting on the basis of the main linguistic divisions of the country. This will give the fullest possible scope for cementing the people together and at the same time assure the preservation and growth of the culture and traditions characteristic of each region.

Taking the ratio of the total antenna power in the different countries to the corresponding area of each, one watt per square kilometre for India appears to be reasonable and satisfactory to start with, in view of the nature of the country and the prevalence of atmospheric disturbances. This gives 4 660 kw of antenna power for the whole of India. The corresponding figures for Denmark, Germany and Great Britain are 1·65, 1·73 and 2·28 watts per square kilometre; and every year sees an increase in them.

Bearing in mind that the most important criterion in the location of each station is the availability of suitable microphone talent in each linguistic area, between 60 and 65 regional stations will probably be adequate to serve all legitimate interests and requirements. On this basis, Hindi and allied languages in the north will have 16 stations; Bengali will have 6, Telugu 5 and so on.

In addition to the 65 stations catering to the regional requirements, five national transmitters located, say, at Lahore, Patna, Nagpur, Bangalore and Rangoon, will put on the air programme matter of national interest. Broad questions relating to international trade, foreign affairs, national defence and economy will come within the purview of these transmitters.

For purposes of long distance international broadcasting, five short-wave transmitters located, for example, at Delhi, Calcutta, Bombay, Karachi and Rangoon, will complete the picture. The country will thus have between 70 and 75 stations.

In the matter of power allocation, each of the five national transmitters will have 250 kw in the antenna and each short-wave transmitter 50 kw. The regional transmitters can be divided into two categories; 45 transmitters each with an antenna power of 25 kw and 20 transmitters each with 75 kw. To take care of inadequately covered areas there will have to be a number of relay stations, the power of none of which will exceed 0·5 to 1·0 kw (Fig. 2).

TELEPHONE LINES.

An adequate system of interconnecting high grade telephone line network for distribution and interchange of programmes and

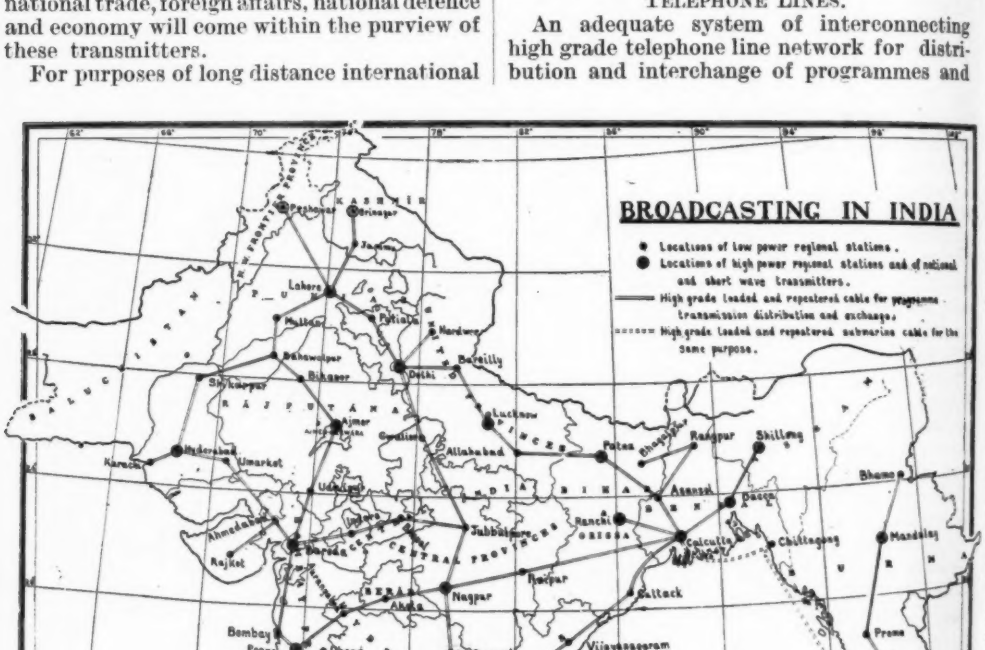


Fig. 2.

for national hook-up whenever necessary is indispensable. Europe and America possess extensive networks of this character. They are absolutely essential in our tropical climate with its generous supply of atmospheric disturbances for at least eight months in the year.

The telephone network suggested here can be divided into (*a*) the Indus system from Lahore to Karachi (1 300 km); (*b*) the Western India system from Lahore to Bangalore through Baroda and Bombay (2 800 km); (*c*) the Mid-India system from Lahore to Travancore through Agra and Nagpur (3 000 km); (*d*) the Gangetic system from Lahore to Calcutta through Delhi and Allahabad (2 000 km); (*e*) the East Coast system from Calcutta to Madras (1 800 km); (*f*) the Bombay-Calcutta system (1 700 km) and (*g*) the Central Burma system (2 000 km). The figures inside the brackets are approximate route distances and total 14 600 km. With two pairs of wires for programme transmission and a similar number for control purposes, the total length of wire pairs in the network will be of the order of 60 000 km. For such a small country as Great Britain, the total wire system used for broadcasting is in excess of 6 000 km.

The above represents in broad outline the picture of the transmitting system.

RECEIVER DISTRIBUTION.

In regard to the distribution of receivers private family ownership is out of question, at least for the present, with a *per capita* income of about Rs. 100. There is no suitable or satisfactory alternative to community ownership of receivers and community listening. The provision of a receiver per cent. of the population giving a total of 3·5 millions for the whole country is a very satisfactory immediate objective. This number for this huge country is very modest. Even now, for every hundred of the population, Denmark has 16 receivers, Great Britain 15·24 and Germany 9·75.

CAPITAL OUTLAY.

The essentially conservative broadcast development plan as visualised above will involve an immense amount of money and effort. No pretence to any great accuracy is possible and the estimated figures of cost given here do not claim to be any more than very roughly representative.

Transmitting equipment investment includes the costs of the transmitter, the antenna, land and buildings, studio and office equipment, etc. The total figure naturally increases with the antenna power of the station.

Category of transmitter	Antenna power in kilowatts	No. of stations	Cost in crores of rupees
Medium power regional	25	45	2·7
High power regional	75	20	3·0
National ..	250	5	1·5
Short wave ..	50	5	0·3
TOTAL ..			7·5

The cost of a receiver is dependent on a variety of conditions; a simple crystal set with a pair of phones need not cost more than Rs. 15 or 20 exclusive of antenna and earth arrangements; at the other end there is the all-mains, all-wave multi-tube modern receiver housed in an excellent looking cabinet which might cost anywhere between a few hundred to a couple of thousand rupees to the ordinary buyer. A community-owned receiver has to be a robust and weather, insect, mischief and fool-proof apparatus, simple to operate and capable of accommodating an audience of, say, 200 persons sitting under a tree or in the village meeting place. The average cost of such a receiver, inclusive of loudspeaker, antenna and power supply is not likely to be under Rs. 300 even with efficient mass production conditions and direct distribution with the barest minimum of intermediary agencies. On this basis, investment on receivers will be to the tune of 105 crores of rupees. The total capital outlay on receiving and transmitting equipment, *exclusive of the telephone network*, will be about 113 crores of rupees.

ANNUAL CHARGES.

In the first place, we have the maintenance and operation charges inclusive of obsolescence, depreciation, salary and power bill, etc. An American estimate of 1930 gave for the average for the world the figure of Rs. 45 per year per installed watt of antenna power. On the assumption of Rs. 20 under Indian conditions the running expenditure for 4 000 kw will be 8 crores of rupees a year.

Receiver maintenance charges per year vary with the type and size of the apparatus and on the average amount roughly to about 25 to 30 per cent. of the initial cost. There is not much to go wrong with the

modern all-mains multi-tube receiver nor at the other extreme the simple crystal set. It is the battery-operated set that is the most expensive and troublesome to maintain, particularly in India. On the basis of Rs. 75 per receiver per year, the annual bill will amount to a little over a minimum of 26 crores.

But in any progressive broadcast service worth the name, payments to artists and other direct expenditure on programmes should form the major part of the annual budget. Voluntary microphone talent, be it never so patriotic or willing, can never be adequate in volume, sustained in quality and varied in composition to be relied upon for any but the briefest part of the daily programme time. By its very nature, programme expenditure is difficult to estimate, varying as it does with the nature and duration of the programme, local conditions and above all, the artist. A minimum figure of Rs. 100 per hour per station will perhaps help to obtain a rough idea of the expenditure on programmes. Assuming an operation time of 4 000 hours per station per year, programme expenditure will amount to about 3 crores of rupees. Any worthwhile programme service will cost much more; it will certainly not be less. Thus the total annual broadcasting bill for the whole nation will be in excess of 37 crores of rupees, *excluding the annual maintenance and operation charges on the telephone network*. This figure should be compared with the annual military expenditure of 45 crores and a total expenditure on education of somewhat under 25 crores.

A nationwide broadcasting service has to be built up; it cannot be brought into existence by wishing for it. Up to date, accurate and comprehensive knowledge and understanding of the status of broadcasting abroad is essential; equally important is it to evolve a well chalked out development programme after careful consideration of all circumstances in order to ensure success from the beginning.

ORGANISATION.

A word may not be out of place in regard to the nature of the organisation. If broadcasting is to be nationwide in scope and national in character as in other countries, there appears to be no alternative to its organisation as a non-political, non-sectarian, national authority of the autonomous public utility type completely free from the slightest suspicion of any trace of control or influence in any shape or form of private commerce. Secondly, in the matter of programme composition and expenditure, the organisation should ensure the daily exercise of the utmost possible freedom in each region in order to be responsive to all worthwhile and ascertainable requirements and tastes of the different regions of the country.

But the engineering and scientific services, equipment and personnel, in regard to every aspect of maintenance, operation, research, development and expansion should at all times be under the undisputed and undivided control of a central all-India body, to secure from the very outset the inauguration and execution of a well-considered and ordered development programme and to assure the maintenance of the highest standards of excellence and efficiency uniformly throughout the land.

There will therefore have to be a Central Broadcasting Council (Fig. 3) whose main functions will be the following:—(*a*) undivided control of all engineering services, development and research throughout the land; (*b*) laying down broad lines of programme policy in consultation with regional broadcast administrations and national advisory councils; (*c*) collection of license revenue through the network of post offices and their distribution; and (*d*) regulation of relations with foreign broadcast administrations and the departments of state. And in all matters of policy and general administration, the Central Broadcasting Council will be responsible through the Minister of Communications to the central, that is, the all-India legislature.

The regional or Provincial Broadcasting Commission (Fig. 4) should be left completely free to devote all its energies to regional programme construction and its financing, in order to provide for the listeners within its region the best possible and varied daily programme of entertainment and instruction. The Provincial Commission will be assisted by a number of consultative committees to advise on policy, and *ad hoc* programme committees to assist in the composition of the daily programme. And in regard to programme policy, programme and allied expenditure and other similar questions within its purview, the Provincial Commission will be responsible through the provincial minister-in-charge to the local legislature. The main regional vernaculars will be the principal languages of broadcasting. Hindi as the principal language of India and English for

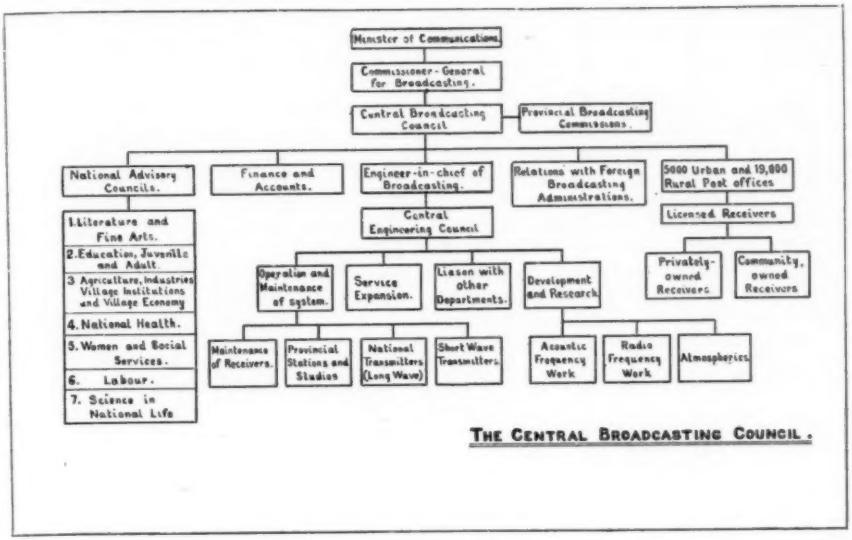


Fig. 3.

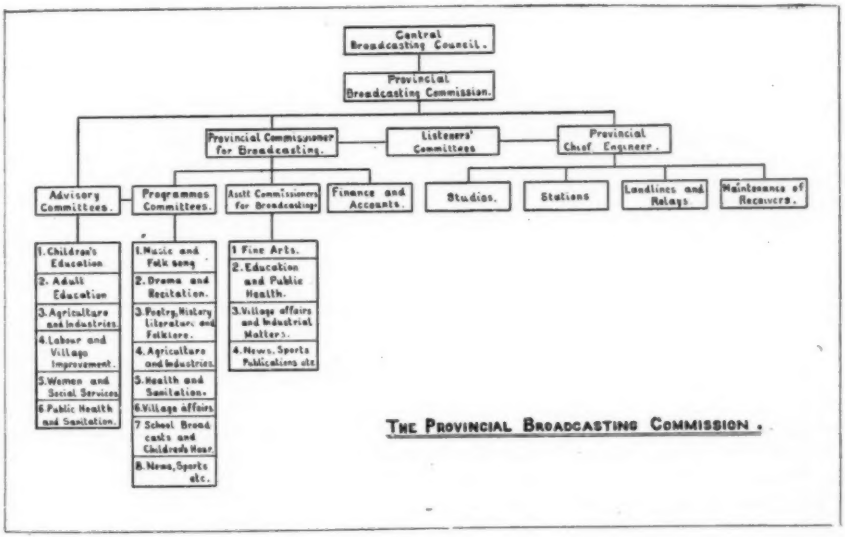


Fig. 4.

international communication will be the other two languages for each station. Only in this way can broadcasting in India earn and retain the trust, confidence and affection of the population and develop increasingly as probably the most beneficent and universal tool for the service of the community.

THE FINANCING OF BROADCASTING.

If broadcasting should be truly national in character and if it should be a matter of personal concern to every individual citizen, it is of the most vital importance that it should be financed entirely by the annual licence fee of the listener and by

direct state subsidy. That will be the most direct and tangible form of the listener's material and moral support and approval of the broadcasting activities throughout the country.

The Central Broadcasting Council will collect the licence fee in convenient instalments through the network of post offices; the postal department will retain about 2 per cent. of the collections for the expenses of collection. Of the rest, the Central Broadcasting Council will take 10 to 20 per cent. for its own expenses and hand over the remainder to the corresponding Provincial Broadcasting Commission which will thus get an amount of money proportional to the number of listeners it has built up in its area.

A second source of income for the central council will be from customs duties on imported radio goods to be handed over to it by the central government. And there is finally the annual subsidy by the government. In these three main ways, the Central Broadcasting Council will derive its revenues to meet its expenditure on general administration and on technical services of all-India character including development and research.

In addition to the proportion of the licence fee collected in its area, the Provincial Broadcasting Commission will obtain an annual subsidy from the local government, the magnitude of which will form a direct measure of the appreciation and approval of its programme service. There will also be some amount derived by the sale of publications. On the side of expenditure, there are (*a*) direct programme expenses, such as payments to artists, etc.; (*b*) payment to the Central Broadcasting Council for the maintenance and operation of transmitting and allied equipment on an agreed rate per hour of operating time; and (*c*) general administration charges.

This method of financing will act as a powerful incentive for each regional administration to improve constantly its programme service to the community. Programme expenditure will account for the major part of the provincial commission's income from all sources.

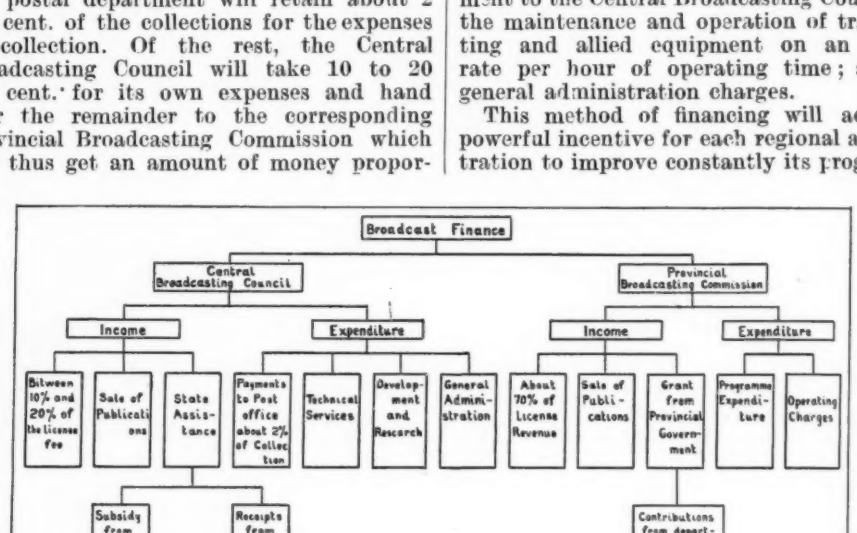


Fig. 5.

PROGRAMME POLICY AND COMPOSITION.

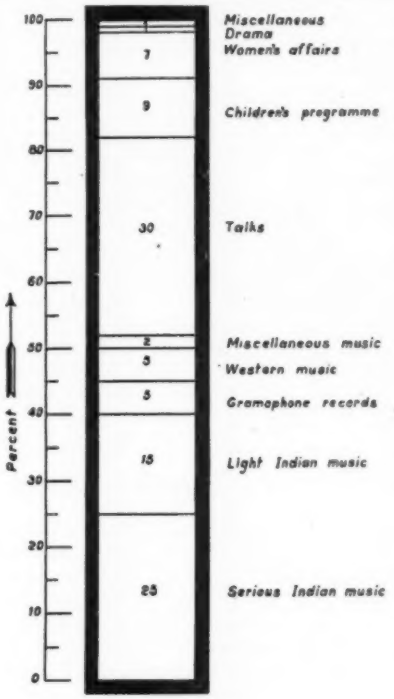
It cannot be too strongly emphasised that the success and popularity of any broadcasting scheme depends upon the programme policy and the character and daily composition of programme. If technical efficiency in apparatus and operation formed the chief criterion for judgment, broadcasting would be an unqualified success wherever money and competent engineering talent are available. If for any reason whatever, the daily programme features cannot attract and

steadily retain the interest and appreciation of the mass of the listeners, the service is best shut down in time ; for the continuation of a poor service will only earn apathy and disgust and prove a set-back to broadcast development under propitious circumstances.

Organised as a public utility and financed partly by public funds, there will inevitably be a tendency on the part of the service to emphasise and subserve unduly the ideas and views of official authority. If broadcasting should develop into a vital living force for good in the daily life of the community, official pressure and interference should be conspicuous by its non-existence except in declared cases of national emergency or of open violation of national policy to the detriment of the welfare of the community. Within the broad confines of a well-thought-out and well-defined general programme policy for the whole country, each provincial organisation should explicitly enjoy and exercise the utmost freedom in making up its programme with a single eye to social well-being and the interest, convenience and necessity of the listening public. On all matters relating to the political, civic and economic duties and privileges of the citizen, public health and sanitation, educational and industrial development, well-planned and insistent propaganda by the ether should form one of the cardinal features of programme policy and composition.

Current topics and subjects of controversy are inherently interesting to the listener. Balanced presentation before the microphone by competent persons of current topics and controversial subjects of every type helps to provoke broader and more reasoned and less lop-sided thought and discussion ; and that is an unmixed blessing all round. In the category of subjects of controversy for treatment before the microphone should be included arts, sciences, politics, social economy, war and peace, international affairs and indeed every subject on which division of opinion can exist, with the sole exception of religion ; in human affairs from the dawn of intelligence, there is no subject which has caused more unreason, unnatural division and strife and threatened to destroy the very springs of elementary commonsense, good-will and neighbourliness. Religion is best ignored in broadcasting.

Fig. 6 shows a suggested division of programme time and is based on an examination of practice in a number of countries.



DISTRIBUTION OF PROGRAMME TIME

Fig. 6.

Space does not permit even the briefest mention of a whole category of important questions relating to broadcasting, such as technical and engineering aspects of nation-wide broadcasting, frequency allocation, television, relations of broadcasting with education, industry and trade, the press, the theatre, the arts and so on.

MANUFACTURE AND RESEARCH.

It is clearly impracticable to import all the necessary transmitting, receiving, wire and a whole category of allied apparatus. To do so would be extravagant and wasteful in every way, in money, experience in technical, manufacturing and other matters, outlet for educated youths, etc. Manufacture of apparatus should be encouraged ; research centres at suitable places under the Central Engineering Council of the central organisation should be established for investigations of problems of broadcasting and radio communication ; well-planned courses of study in electrical communication and broadcasting on the absolutely indispensable

basis of a sound foundation in electrical and mechanical engineering should be inaugurated.

The first and the only satisfactory starting point is for the Central Government to send out under its authority an inquiry commission consisting of a businessman, an educationist of knowledge and experience, a lawyer-statesman and a radio engineer and, if necessary, one or two more members. They should travel extensively, visit stations, studios, radio and allied research laboratories, factories and engineering educational institutions; they should discuss the various aspects of the problem with engineers, educationists, broadcast administration authorities, politicians, etc. The State should take action on the recommendations of such a commission based on its observation and intensive study of the whole status of broadcasting abroad.

It is hoped that the above will help to create a correct perspective of the vast problem and provoke reasoned discussion on what is inherently a national question. No more extravagant claim is made than that it will offer some concrete basis for such discussion. It is realised that within the limitations of an article in a periodical, it is impossible to go beyond merely scratching the surface of this vast problem.

It is with pleasure that I express my warm thanks to Mr. T. R. Ramachandra Iyer for his very kind assistance so willingly given.

Asiatic Society of Bengal—Annual Meeting, 1935.

THE Annual Meeting of the Society was held on the 4th February with Dr. L. L. Fermor, O B.E., D.Sc., F.R.S., President of the Society, in the Chair.

In the course of his Presidential Address Dr. Fermor dealt with the development of scientific research in India. "Starting with the comprehensive treatment of such research provided for by the foundation of the Asiatic Society of Bengal in 1784, the subsequent story has been, until recently, one of increasing specialisation. This specialisation was slow until after the middle of the nineteenth century, when the tendency began to develop force. By the beginning of the twentieth century, rapidly increasing specialisation with the formation of a multitude of new specialist organisations was in full swing. But fortunately at about the same time the necessity for co-ordinating bodies became recognised, and this had led successively to the formation of the Board of Scientific Advice (1902-1924) of the Indian Science Congress Association (1914 to date) and finally of the National Institute of Sciences of India. This final development is in accordance with the genius of our Society, for concurrently with the spate of specialist tendencies and activities, your Society has always maintained its broad general basis, showing its generosity as the mother of new developments often of a specialist nature whilst preserving its position as a philosopher's garden where all may walk and talk."

The following awards were made:—

Elliot Prize for Scientific Research.—The Prize for the year 1933 was awarded to Mr. N. K. Sen of Dacca University for his contributions to Chemistry. The Prize for 1934 was for Physics and Dr. D. P. Roy Chaudhuri is the recipient of the Prize. The Prize for 1935 will be for work in Geology and Biology (including Pathology and Physiology) regarding which a detailed announcement has been published in the *Calcutta Gazette* and the *Bihar and Orissa Gazette*.

The Sir William Jones Memorial Medal.—This medal is awarded biennially for conspicuously important Asiatic researches with reference alternately to (1) Sciences, and (2) Philosophy, literature and history. This year the medal is for Science and has been awarded to Rai Sir Upendra Nath Bramhachari Bahadur, Kt.

Brühl Memorial Medal.—This medal is awarded every three years for conspicuously important contributions to the knowledge of the Asiatic Botany. This year the medal is awarded to Mr. I. H. Barkill, Late Director of Gardens, Straits Settlements.

Indian Science Congress, Calcutta, Prize.—This prize is awarded in such years as the Session of the Congress is held in Calcutta for conspicuously important services to the Indian Science Congress. The Prize is awarded to Dr. Meghnad Saha, F.R.S., with special reference to his work for the Indian Science Congress.

From an evening lecture delivered on 3rd January 1935 in the Senate House of the Calcutta University in connection with the Calcutta Meeting of the Science Congress.

Structure of the Nucleus.

By Rao Bahadur Prof. B. Venkatesachar, M.A., F.INST.P.

FROM ancient times there have been two views of the constitution of matter. One school represented by Democritus considered matter and even space as made up of discrete and indivisible particles or atoms. The other view advocated by Anaxagoras was that matter was continuous and infinitely divisible. The *Nyaya* school in India championed the atomic viewpoint, considering the atoms to be one-sixth the size of a mote in a sun-beam. The development of chemistry in the 19th century, beginning with the work of Dalton, placed the atomic theory in an impregnable position. Elements and compounds were distinguished and every element was thought of as made up of similar, indivisible and immutable atoms. Research was concentrated on discovering the various elements and establishing their atomic weights. As late as 1907 Lord Kelvin in his address to the British Association said, "It seems indeed *almost* absolutely certain that there are many different kinds of atoms each eternally invariable in its own specific quality and that different substances such as gold, silver, copper, oxygen, nitrogen, hydrogen, consist each of them of atoms of one invariable quality, and that every one of them is incapable of being transmuted into any other." It was fortunate that Lord Kelvin only said "almost certain"; the small chance to the contrary implied in the word "almost" has been shown by later research to represent the true state of affairs, and our generation has witnessed the successful carrying out of such transmutations as were not dreamt of even by the alchemists of old.

Germs of modern ideas were seen in Prout's hypothesis that all the elements were built up from hydrogen. The fact that the weights of the atoms of various elements were not integral multiples of that of hydrogen was a difficulty which discredited this hypothesis. But the work of Aston has shown that the elements really consist of atoms with different weights all possessing the same chemical properties. These are known as isotopes and the weight of each isotope is almost an integral multiple of that of hydrogen. The difference from an integral value does not disturb our scientific equanimity nowadays. The theory of Relativity has shown that such a difference is a measure of the stability of the atoms. It is an index in fact which shows how any element may be thought of as built up of various constituents and in what direction we may expect a successful transmutation.

In radioactive phenomena nature herself exhibits such transmutations. The study of radioactivity revealed the existence of three different kinds of radiation, *viz.*, the α- β- and γ-rays. The β-rays are streams of fast-moving particles of negative electricity, *viz.*, electrons. J. J. Thomson's work on cathode rays established the fact that the electrons were constituents of all atoms, and that their mass was only a minute fraction of that of the hydrogen atom. Thus the problem of the structure of atoms arose and the atoms were no longer conceived as indivisible. α-particles were shown to be helium atoms which had lost two electrons, while the γ-rays were found to be light-waves of extremely short length. Since all atoms are neutral and the electron with its negative charge is part of every atom, how is the other, the positively charged part, constituted? Rutherford's experiments on the scattering of α-particles by matter showed that the massive positively charged part of an atom was concentrated into a small compass with the electrons distributed at great distances from this central part or nucleus. The nucleus thus resembles the sun and the planets are represented by the electrons. The number of planetary electrons is determined by the positive charge on the nucleus and the chemical properties of the various elements are determined by the number of these external electrons. The nucleus carries almost the whole of the mass of the atom and is thus characterised by its weight—the atomic weight—, and its positive charge, *i.e.*, the atomic number. This nuclear theory of the atom has been confirmed by all later experience and now rules unchallenged in Physics.

The phenomena of radioactivity show that the nucleus also is composite, and at the present moment the problem of the structure of the nucleus looms large in the scientific work of prominent physicists. The fact that a radioactive element retains its activity whether it is uncombined or combined with other elements, shows that the emission of α- and β- particles must take place from within the nucleus. Thus every nucleus must be supposed to contain α-particles and electrons. If α-particles are to remain inside

in a stable structure, the electrostatic repulsion between an α-particle and the rest of the nucleus must have been converted into an attraction. But Rutherford's experiments on the scattering of α-particles of Th'(C') by Uranium, *e.g.*, have shown that Coulomb's law holds up to distances of 3×10^{-12} cms. Thus the law of force should be Coulombian repulsion upto distances of this order and then change into one of attraction. Or if we speak of the potential at different distances from the nucleus, it should go on increasing from large distances till at some very small distance it begins rapidly to decrease and then attains a negative value, *i.e.*, the potential curve should show a high peak at some distance from the nucleus. This distance we may speak of as the radius of the nucleus. In the case of Aluminium the distance of this potential peak is estimated to be 4×10^{-13} cms. while the height of the barrier is about $7{\cdot}5 \times 10^{6}$ electron volts. In the case of Uranium we have seen that α-particles can reach to a distance of 3×10^{-12} cms., *i.e.*, the potential barrier must be higher than

$$2Ze^2/r = \frac{2 \times 92 \times 4{\cdot}77^2 \times 10^{-20}}{3 \times 10^{-12}} = 13 \times 10^{-6} \text{ erg.}$$

But α-particles of energy 6×10^{-6} erg are emitted by Uranium in radioactive changes. How do these α-particles cross a potential barrier of at least twice their energy ?

The answer to the above question was given by Gamow on the basis of wave mechanics. According to this point of view every particle must be also supposed to have a wave-like aspect just as light waves behave like particles (photons) in some experiments. Every particle of mass m and velocity v is equivalent to a wave of wave-length $\frac{h}{mv}$. Some experiments like those of G. P. Thomson or Davisson and Germer show the wave-like nature of electrons, while others such as the deflection of cathode rays by electric and magnetic fields show the particle nature of these same electrons. Similarly, interference, diffraction and polarisation show the wave-nature of light, while photo-electricity and the Compton effect show its particle nature. As in the case of Dr. Jekyll and Mr. Hyde, we see sometimes one aspect and sometimes the other, but never both together. According to Gamow's theory the α-particles in their wave-aspect can penetrate through the potential barrier and have a finite chance of coming out on the other side. This is one of the triumphs of the new mechanics.

We have already seen that even the nucleus must be complex, containing α-particles and electrons. The assumption of free electrons inside the nucleus leads to a number of difficulties in connection with the spin and magnetic moments of nuclei. The discovery of the neutron by Chadwick has helped to remove this difficulty. The neutron is an uncharged particle having a mass nearly equal to that of a proton or hydrogen nucleus and is emitted when Beryllium and Boron are bombarded by α-particles from polonium. Being uncharged, it has great penetrating power. Its constitution is not known, but it must be assumed to be capable of giving off an electron or its positive counterpart—the positron—in radioactive processes. The assumption that all nuclei consist of α-particles, neutrons and one or no proton according as the atomic number is odd or even removes a number of difficulties such as the one above mentioned regarding the spins of nuclei. Venkatesachar and Subbaraya also showed a way of accounting for the spins and magnetic moments of nuclei. They assumed according to the then current views that a proton has a magnetic moment equal to 1/1845 times that of an electron, but Stern has obtained a value about 2·5 times as much. Though there are still some differences of view regarding details, the general way of accounting for the magnetic and spin moments of nuclei by the spin and orbital motions of the particles inside the nucleus is accepted.

Further progress in the study of the nucleus has been made possible by the discovery of heavy hydrogen (Prof. Urey has received the Nobel Prize in Chemistry for this achievement), and of the positron which has the same mass as the electron but has a charge of opposite kind. Anderson and Neddermeyer and Curie and Joliot have shown that a positron-electron pair results from the materialisation of a γ-ray, in which process the nucleus acts as a catalyst to conserve momentum during the change. Dirac's theory also shows that when a positron and electron unite, two γ-rays will be produced and this has been observed by Gray and Tarrant. Thus the conversion of matter into radiation and radiation into matter has been accomplished and Einstein's relation between energy and its equivalent mass, *viz.*, $E = mc^2$ has been amply verified.

Another line of enquiry started by Rutherford when he succeeded in transmuting Nitrogen into Oxygen with emission of hydrogen by bombarding Nitrogen with α-particles has been followed up in recent years with great success. Almost every element has now been converted into some other and new radioactive elements have been artificially produced by Curie and Joliot and Fermi and others. The missiles at the disposal of the physicist have also multiplied; α-particles, protons, diplons (heavy hydrogen nuclei) and neutrons have all been employed for this purpose. Cockcroft and Walton and Lawrence and others have refined experimental technique to such an extent that protons and deutons can now be given energies almost equivalent to that of the α-particles provided by Nature and the corresponding progress in the programme of transmutation has been extensive. Thus when Li_6 is bombarded by a deuton or Li_7 by a proton we get two α-particles which have about ten times the energy of the bombarding particles. The internal energy of the nucleus has thus been set free to some extent. Who shall limit the possibilities inherent in this achievement? Gladstone lived to levy a tax on an industry developed from Faraday's discovery. Hertz's discovery has revolutionised modern methods of communication. What practical possibility lying latent in the nucleus may not become an accomplished fact and what revolutions may it not bring about?

North Bihar Earthquake of January 15, 1934.*

By S. K. Banerji,

Meteorological Department, Poona.

THE earthquake which occurred in North Bihar on January 15, 1934, had many important peculiarities. The shock was felt over an area of not less than 3 million square miles—an area which is perhaps greater than that of any earthquake recorded during the last 100 years. An important feature which has been prominently brought to notice is the inequality of propagation of surface vibrations in different directions. These were felt at greater distances towards the south and the west than the north and the east, the Himalayas in the north and the Assam and Burma mountains in the east acting as barriers and damping them out considerably. That these mountain folds and the fault planes which bound them should obstruct the normal propagation of surface waves is what we should expect from the theory of elasticity.

An earthquake of severe intensity has usually an energy of the order of 10^{21} ergs but the present earthquake appears to have energy slightly greater than 10^{22} ergs. There are several methods by which the calculation of the energy of the earthquake can be made, but the simplest one is to use the results obtained theoretically by Nakano that for an earthquake of shallow focus 0·4 of the energy sent out from a compressional disturbance and 0·9 of that from a distortional one goes into surface waves. If then we estimate by means of seismograms the velocity of ground movements at some fixed distance, say 200 km., all round and also estimate the length of the wave train carrying most of the energy, we can immediately calculate the total energy of the earthquake. To illustrate the method of calculation, we would estimate that the mean velocity at a distance of 200 km. was 250 cm/sec. Since the mean density of surface rocks is about 2·7, the kinetic energy per unit volume is 9×10^4 ergs. On the average the potential energy is the same as the kinetic energy, and, therefore, the total energy per unit volume is $1{\cdot}8 \times 10^5$ ergs. Now the length of the part of the wave train carrying most of the energy

= mean velocity of surface waves × time taken to pass over a given place

$= 1 \times 10^5 \times 10 \times 60 = 2{\cdot}4 \times 10^8$ approximately.

Integrating over a circle of radius 200 km., we see that the energy of surface vibrations

$= 1{\cdot}8 \times 10^5 \times 2{\cdot}4 \times 10^8 \times 1{\cdot}2 \times 10^8 = 5 \times 10^{21}$ ergs.

According to the results obtained by Nakano, this is only a fraction of the total energy. Taking dissipation and other factors into account it would seem that the total energy is slightly greater than 10^{22} ergs. It is easily seen that this estimate of the total energy is not much affected, if we estimate a slightly greater or smaller value for the velocity

* Based on the opening speech at the symposium held at the Indian Science Congress, 1935.

or the duration of the length of wave train or both at a distance of 200 km.

An energy of the order of 10^{22} ergs could be produced by the fracture of a quadrangular rock of dimensions 150 km. × 100 km. and thickness 10 km. If a be the length, b the breadth, and $2h$ the thickness of a quadrangular rock, then its potential energy when bent by couples is

$$\frac{1}{3}\frac{Eh^3}{1-\sigma^2}\left[\left(\frac{1}{R_1}+\frac{1}{R_2}\right)^2-2\,(1-\sigma)\,\frac{1}{R_1R_2}\right]ab$$

where R_1, R_2 are the radii of curvature, E the Young's modulus and σ the Poisson's ratio. When the rock cracks, this energy is released. It is important to notice that this expression involves thickness in the third power but the length and breadth only in the first power. It is, therefore, the thickness which contributes most to the amount of energy released. We have no observational evidence in regard to the amount of bend which a plate of rock of large dimensions can stand before rupture, but, according to definition, if O is the centre of the rock, and if a plane through the normal and a principal axis of the indicatrix cut the extremities of the rock in the diameter QVQ′, then the radius of curvature R is given by $2R \cdot OV = QV^2$. But QV is either 75 km. or 50 km. according as the plane passes through the major or the minor axis of the indicatrix. It would be safe to assume that the rock will crack if OV become as large as 100 metres† (Fig. 1). This would make R_1 and R_2 to be of the

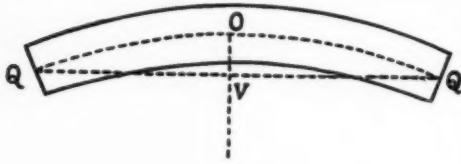


Fig. 1.

order 10^{10} cm. and 10^9 cm. respectively. With these values for R_1 and R_2 it is easily seen from the formula that the amount of energy which would be released by a bent quadrangular rock of dimensions 150 km. × 100 km. × 10 km. is of the order of 10^{22} ergs. If the thickness was less than 10 km., its length and breadth would have to be considerably greater than 150 km. and 100 km. respectively in order to give the energy of this magnitude. This would suggest that the focus of this earthquake must have covered a wide volume and the epicentral tract a fairly wide area. This is confirmed by the observations[1] made by the Geological Survey.

The very great preponderance of surface waves in this earthquake, as well as the type of movements in the preliminary and the secondary phases all suggest that this earthquake had a shallow focus.[2] If we estimate the depth of focus from the relative importance of the different phases in the seismogram, we find that its upper surface was probably not lower than 15 km. From an analysis of the 'delay in starting' of the phases $\overline{P}$, P*, P, $\overline{S}$, S*, S, Ray[3] has recently estimated the depth of focus to be about 13 km. With this information in our possession, the question arises whether the theory of elasticity can make any definite contribution to the search for the cause of this earthquake.

It is almost certain that isostatic compensation holds in the case of such large mountains as the Himalayas. For, suppose that compensation did not hold, and that the Himalayas could be supported by the strength of the crust and the substratum. Calculation by the method given by Love[4] shows that the stress differences required to support mountains of height 10,000 metres above the adjacent valleys in a uniform crust would be about 10^9 dynes/cm.^{2} This is near the crushing strength of basalt, which could, therefore, just support the Himalayas if the stresses necessary could be distributed over an infinite depth. The Himalayas apart from being very high are of such large horizontal extent that they would produce breaking stresses in the lithosphere assumed to be of finite thickness. It is therefore very likely that they are bounded by fault planes so that they can move up and down independently, that is to say, float on the lithosphere and undergo up and down movements without disturbing the

† Surface earthquake waves which usually have wave-lengths of 60 or 70 km. invariably cause extensive cracks if they have amplitudes as large as one metre. The estimate of 100 metres for OV would thus appear to be an overestimate and not an underestimate. A smaller value for OV would require greater thickness for the rock to yield the same energy.

[1] *Rec. of the Geological Survey*, 1934, **38**, 177.

[2] *Phil. Mag.*, 1925, **49**, 65.

[3] *Curr. Sci.*, 1935, **3**, 298.

[4] *Some Problems of Geodynamics*, pp. 38–48; *Jeffrey's Earth*, pp. 178-202.

surface crust over the continents. But can relationship between the mountains and the continent be so simple as this? The fault planes being planes of fractures are probably inclined to the vertical. A clear gap does not apparently exist. There are probably huge rocks connecting the mountains and the continents across the fault planes. Any upward or downward movement of the mountains will necessarily introduce considerable stress in these rocks and if the elastic limit is reached, breaking will occur. Was a process like this the cause of the present earthquake? The upward motion of the mountains can of course occur as a consequence of denudation and if they are floating more or less independently of the continents the gravity anomalies found in the Gangetic plain and elsewhere are probably not of much importance as undoubtedly the strength of the continental crust, *i.e.*, the cohesion of the materials forming the continental crust, is able to support a small departure from perfect isostacy.

A theory of the above kind can only stand if it can be supported by geological observations. Such observations[5] have shown that the main epicentral tract has the form of an elongated ellipse and that it is situated at a distance of about 35 km. from the boundary fault (Fig. 2). If P be the greatest principal stress at any point in a rock and R be the least, the fault planes will, according to the theory developed by Mohr, Navier and others, be inclined at angle θ to the direction of P, given by $(P - R)(\sin 2\theta + \mu \cos 2\theta) - \mu(P + R) = a$ maximum. This equation means that along the planes of fracture the tangential stress diminished by the resistance to movement which is due to internal friction must be maximum, and gives $\theta = 22\frac{1}{2}°$ for $\mu = 1$. This result[6] is supported by observations, for, in the case of normal faulting it is known that P is very nearly vertical and R horizontal, and that normal faults are inclined to the vertical at an angle slightly greater than $22\frac{1}{2}°$. The faults cannot, however, be along a straight line, such as OA (or OA'

[5] *Rec. of Geological Survey, ibid.*

[6] *Beiträge Zur. Geophysik*, 1934, **43**, 5.

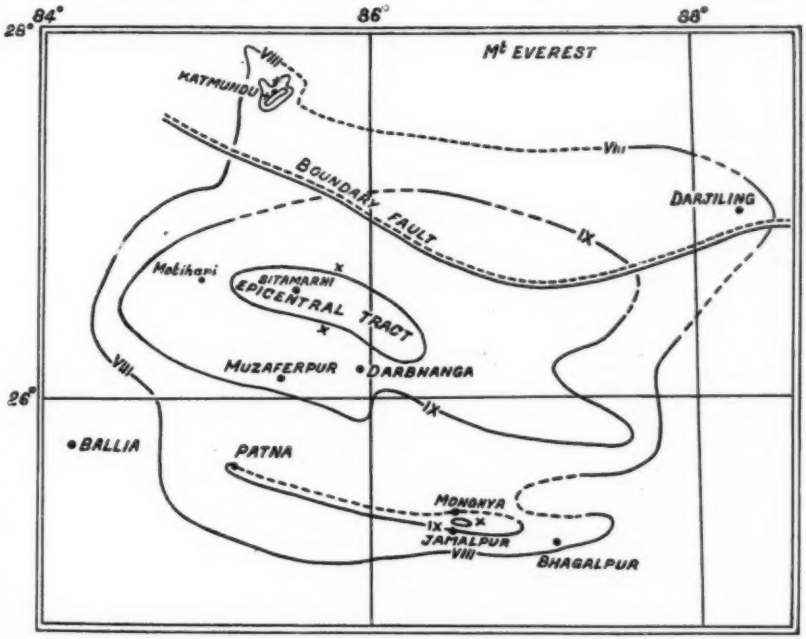


Fig. 2.

Epicentral Tract, isoseismal lines and boundary fault
(Based on the *Report of Geological Survey of India*).

if θ has a greater value than $22\frac{1}{2}°$) (Fig. 3).

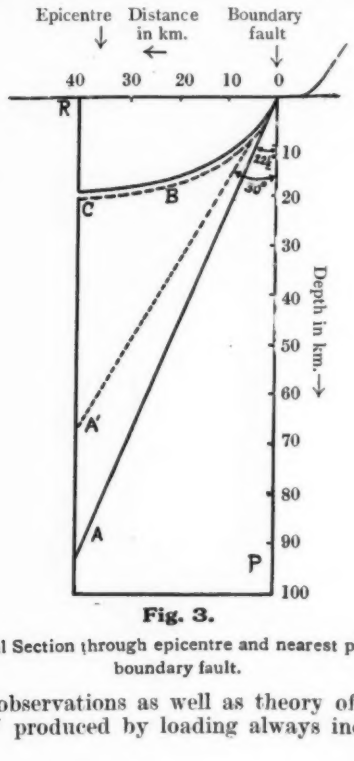


Fig. 3.

Vertical Section through epicentre and nearest point of boundary fault.

For, observations as well as theory of fractures[7] produced by loading always indicate that they lie along a curve such as OBC. The depth of the faults below the observed epicentral tract will therefore be about 20 km., and if an elongated rock of dimensions 150 km. × 100 km. and thickness 10 km. (rectangular, elliptical or other shape) was lying across the fault at this depth and was strained, it could by fracture give the energy required for the production of the earthquake. The two subsidiary epicentral tracts near Khatmandu and Monghyr were probably induced by a major crack of this kind.

The earthquake occurred on a new moon day, and on such a day we get a body tide due to the elastic yielding of the solid material of the earth, such that the height of the oceans, as measured by the rise and fall of the sea, relative to the land is reduced to about $\frac{2}{3}$ of the true equilibrium height (if the rigidity of earth be assumed to be the same as that of steel). On that day also an atmospheric disturbance was passing over Northern India and Darwin has shown that if the difference of barometric pressure between consecutive regions of "high" and "low" pressures be 5 cm. of mercury and if the centres of "high" and "low" be 1,500 miles apart, then as a consequence of the yielding of the ground, it will be 9 cm. higher under the barometric depression than under the elevation. These causes could, therefore, conceivably have served to produce a kind of trigger action.

[7] Banerji, *Bulletin Cal. Math. Soc.*, 1921, **12**, 93.

Some Recent Advances in Indian Geology.*

By W. D. West,
Geological Survey of India.

5. The Geology of Salt Range.

THIS comparatively small range of mountains in the northern Punjab has long been regarded as the show locality of Indian geology. Its fairly complete geological record, its abundant fossils and its complicated structure have combined to make it a place of great attraction to geologists. Bound up with the correct interpretation of its structure is the question of the age of the Saline series, concerning which almost every geologist who has visited the Salt Range seems to have propounded a theory. The problem, it will be recollected, lies in the fact that while in the Salt Range the Saline series underlies rocks of Cambrian (or possibly pre-Cambrian) age, in the Kohat district, only 17 miles away, it underlies rocks of Upper Nummulitic (Middle Eocene) age. And since in the latter place it was considered by D. N. Wadia and L. M. Davies to be of lower Eocene age,[1] a view subsequently corroborated by E. R. Gee,[2] its stratigraphical position in the Salt Range was difficult to understand.

There is no need to summarise the early stages of this controversy. Suffice it to say that Sir Edwin Pascoe, as a result of his

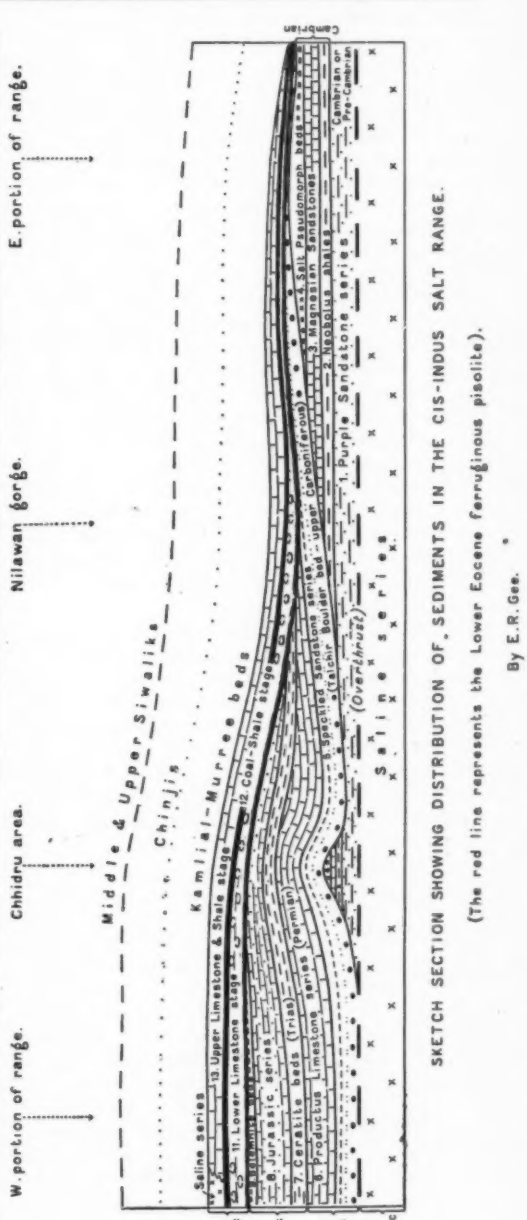
* Published with the permission of the Director, Geological Survey of India.

[1] *Trans. Min. Geol. Inst. Ind.*, 1929, **24**, 202.

[2] *Rec. Geol. Surv. Ind.*, 1931, **65**, 20; and *Curr. Sci.*, 1934, **2**, 461.

studies of the oil-bearing strata of north-western India, suggested a Tertiary age for the salt deposits of both the Salt Range and the Kohat area. This view necessitated the introduction of an overthrust between the Saline series of the Salt Range and the overlying Cambrian beds.[3] The chief objection to this view was that no Salt Marl had been found in the Tertiary rocks of the higher parts of the Salt Range. Subsequently C. S. Fox, as a result of a visit to parts of the range, gave reasons for reverting to the Cambrian age of the salt,[4] a view which also received some support from the fact that salt deposits were found in Persia associated with Cambrian rocks.[5] More recently, G. de P. Cotter, after first accepting a Cambrian age as probable on the balance of evidence,[6] has now supported the view that the Saline series is of Ranikot age, suggesting that its place of original deposition was in the Soan geosyncline to the north of the Salt Range, and that during folding movements associated with the final uplift of the range and of the Kala Chitta hills some of the salt marl was intruded southwards into its present position beneath the Cambrian beds.[7] It has to be admitted, however, that owing to the thick covering of upper Tertiary rocks in the Soan geosyncline of the Potwar, the Saline series is nowhere seen *in situ* in its supposed original position beneath the Laki beds.

In the midst of so much speculation it is refreshing to know that during the past six years a careful re-survey of the Salt Range has been carried out by E. R. Gee whose mapping has been continued westwards across the Indus to link up with the *trans*-Indus ranges and with the Kohat salt region to the north. A summary of the conclusions that have resulted from this survey has, in so far as the Saline series is concerned, already been published in *Current Science*.[8] In this Gee maintains that the Saline series of the Salt Range area is essentially *in situ*, and that the deposit is homotaxial with that of the Kohat salt region and with the Nummulitic limestone and shale deposits of Lower



SKETCH SECTION SHOWING DISTRIBUTION OF SEDIMENTS IN THE CIS-INDUS SALT RANGE.

(The red line represents the Lower Eocene ferruginous pisolite).

By E. R. Gee.

Eocene age which cover wide areas in north-western India.

[3] *Mem. Geol. Surv. Ind.*, 1920, **40**, 358-371.
[4] *Rec. Geol. Surv. Ind.*, 1928, **61**, 147.
[5] *The Structure of Asia*, 1929, **3**.
[6] *Proc. Eighteenth Ind. Sci. Congr.*, 1931, 295.
[7] *Mem. Geol. Surv. Ind.*, 1933, **55**, 149-156.
[8] *Curr. Sci.*, 1934, **2**, 460-463.

To make clear the latest views on the stratigraphy of the Salt Range, a diagrammatic section showing the general geological sequence is given, for the construction of which I am much indebted to Mr. Gee. In this simplified section, taken roughly along the length of the range, the lateral variations in the sequence are indicated. Two marked unconformities are shown. One separates the Lower Palæozoic from the Upper. Along this line the Talchir boulder bed (Upper Carboniferous) overlaps successively westwards across the Salt Pseudomorph beds, the Magnesian Sandstone and the Neobolus Shales on to the Purple Sandstone strata, and finally, as a result of overthrusting, comes to rest directly on the Saline series of the western part of the range. This unconformity with overlap has been discussed by R. D. Oldham and C. S. Middlemiss.[9] That the overlap is less regular than was previously supposed has recently been pointed out by Gee, local exposures of the fossiliferous Cambrian beds cropping up around Chhidru in the western half of the range.[10]

The second large unconformity, first recognised by A. B. Wynne, occurs beneath the Eocene nummulitic rocks. It is marked by a thin irregular bed of ferruginous shale, often pisolitic, which evidently represents an old land-surface. In the extreme east this ferruginous pisolite rests on Talchir shales, in the middle portion of the range it overlies the Productus Limestone, while in the western half it lies on various horizons of the Mesozoic rocks. The nummulitic rocks above the unconformity were, until recently, regarded by most observers to be Laki in age. It has now been discovered that at least the lower portion of the sequence is Ranikot in age.[11]

A third unconformity, less marked in the field than those above-mentioned, but none the less important, is represented by the junction of the Murree Kamlial beds with the underlying Nummulitic Limestone.[12] This unconformity was thought by earlier workers to represent the whole of the Oligocene; recent work by Pilgrim, Cotter and Lahiri has enabled its limits to be more clearly defined.[13]

Regarding the exact age and correlation of the various rock groups, much palæontological work still remains to be done. Recent fieldwork by Gee, however, has shown the close relationship in age between the Neobolus Shales, the Magnesian Sandstone and the Salt Pseudomorph beds, all of which are probably Cambrian.[14] As regards the underlying Purple Sandstones, Fox has stated that they are conformably overlain by the Neobolus Shales, and he places both in the Middle Cambrian.[15] Gee has found in places that the Neobolus Shales rest with a thin basal conglomerate on the Purple Sandstones, and he regards the latter as Cambrian or pre-Cambrian. No fossils have so far been found in them.

Coming now to the Upper Palæozoic rocks, plant remains of lower Gondwana type have been found by Gee in shales overlying the Talchir boulder bed,[16] whilst higher in the sequence, in similar carbonaceous shales among the lower half of the Productus Limestone, Cotter had previously discovered Gangamopteris and Glossopteris.[17] The Warcha section of the Productus Limestone has been described by Cowper Reed, Cotter and Lahiri.[18] In the Jurassic beds, which include a thick sequence in the western part of the Salt Range and which are also well represented in the *trans*-Indus ranges, an Upper Gondwana flora has recently been found by Gee.[19]

It will be remembered that the Nummulitic series (of which only the lower half is represented in the Salt Range) includes the Salt Range coal seam in the eastern half of the range, where the seam occurs not far above the ferruginous pisolite. Traced westwards, however, thick nodular foraminiferal limestones come in below the coal, while the latter passes into a carbonaceous shale, as originally described by Wynne. In the western part of the Salt Range, however, near Daud Khel, exposures showing the lateral passage of the upper limestone (above

[9] *Rec. Geol. Surv. Ind.*, 1886, **19**, 127-131; and *op. cit.*, 1891, **24**, 21-24.

[10] *Op. cit.*, 1234, **68**, 115-120.

[11] Director's Annual Report for 1934 (in the press).

[12] *Mem. Geol. Surv. Ind.*, 1933, **55**, 101-104.

[13] *Rec. Geol. Surv. Ind.*, 1910, **40**, 185; and *op. cit.*, 1933, **43**, 261, and reference 12 above.

[14] *Op. cit.*, 1934, **68**, 115.

[15] *Rec. Geol. Surv. Ind.*, 1928, **61**, 147.

[16] *Op. cit.*, 1933, **67**, 22.

[17] *Op. cit.*, 1930, **62**, 443.

[18] Reference 16, 412-443.

[19] *Op. cit.*, 1929, **62**, 163.

the coal-shale stage) into massive gypsum have recently been discovered by Gee, together with evidence indicating the passage of the underlying coal-shale stage into salt-bearing marl.[20] Both the gypsum and the marl belong to the Saline series. It is concluded, therefore, that the Saline series of the Salt Range (and of Kohat) represent local saliferous facies of Lower Nummulitic (Lower Eocene) sedimentation. This critical section, which appears to have been overlooked by previous observers, apparently provides decisive evidence regarding the age of the Saline series.*

Above the Nummulitic series of the Salt Range the middle and upper Tertiary freshwater strata cover wide areas northwards across the Potwar plateau and the Kohat area, and to the west. These sediments, the vertebrate fauna of which has been studied by G. E. Pilgrim, have recently been studied in detail by R. van V. Anderson and by Cotter and Lahiri.[21]

Regarding the structure of the Salt Range, opposing views have been put forward. Some geologists have interpreted the observed relations of the rocks as being due to overthrusting.[22] C. S. Fox, on the other hand, has endeavoured to explain these structures without the assistance of dynamic forces, attributing them to isostatic movements which have resulted from a relatively plastic salt marl having underlain the higher strata of the Salt Range.[23] Gee, however, appears to be convinced that at least the larger folds, overfolds and thrusts are definitely of tectonic origin.[24] In order to explain the presence of the Saline series beneath the Lower Palæozoic rocks of the range, he postulates an immense regular thrust along which the rocks have moved towards the south in the Salt Range and towards the east in the *trans*-Indus ranges in post-Nummulitic and pre-Siwalik times (*i.e.*, late Eocene and Oligocene), involving a movement of not less than 20 miles. The *nappe* involved in this primary thrust included the Nummulitic and underlying rocks of the Potwar, Kohat and Bannu areas, and continued further afield to link up stratigraphically with the rocks of what are now the Himalaya and Sulaiman ranges. He thinks that a second period of acute tectonic movement commenced in the late Tertiary and continued into sub-Recent times, the forces coming from the same northerly and westerly directions. Owing to the fact that the Salt Range and *trans*-Indus rocks had already, at the time of this second period of earth-movement, approached closely to the Archæan *massif* to the south, of which remnants are now exposed in the Kirana hills, further movement towards the south was impeded, and the forces were spent in causing the acute folding and duplication by overfolding and shearing of the Salt Range strata. During this second period of earth-movement the Saline series was lying beneath the beds of the primary *nappe* and was therefore folded and sheared along with the latter as though it were a portion of a normal stratigraphical sequence. It is in this way that he explains the intimate relationship of the Saline series and the Palæozoic rocks of the Salt Range. A fuller account of these conclusions regarding the age of the Saline series has already appeared in *Current Science* for June, 1934.

6. Epilogue.

In bringing to a close this series of short articles outlining the main lines along which recent work in Indian geology has been developing, I may refer very briefly to certain researches which for various reasons I have omitted to discuss. Chief among these is the recent work which has been carried out on the geology of the Gondwana system. This has been done in the main by C. S. Fox and H. Crookshank, who have added considerably to our knowledge of this important period of Indian geology. For a general account of the geology of these rocks the reader is referred to Fox's recent memoir on the Gondwana system,[25] which forms a part of this great work on the coalfields of India; while the Gondwana rocks of part of the Satpura hills in the Central Provinces have been described by Crookshank in a memoir which is now in the press.[26] Perhaps the most interesting

[20] *Curr. Sci.*, 1934, **2**, 460-461.

* In a paper read by Messrs. P. Evans and M.A. Majeed, of the Burma Oil Co., Ltd., at the recent meeting of the Indian Science Congress, further evidence, based on the examination of heavy mineral residues, was brought forward in support of the Tertiary age of the Saline series of the Salt Range.

[21] *Bull. Geol. Soc. Amer.*, 1928, **38**, 665; and *Mem. Geol. Surv. Ind.*, 1923, **55**, 99.

[22] *Mem. Geol. Surv. Ind.*, 1920, **40**, 358-371.

[23] Reference 15.

[24] Reference 8.

[25] *Mem. Geol. Surv. Ind.*, 1931, **63**.

[26] *Op. cit.*, **66**, Part 2 (in the press).

discovery in Gondwana geology has been the find by K. P. Sinor near Umaria in Central India of a marine fauna in rocks which had hitherto been regarded as wholly continental in origin.[27] These rocks were subsequently mapped by E. R. Gee,[28] and the fossils found in them described by F. R. Cowper Reed.[29] Reference should also be made to Sir Thomas Holland's presidential address to the Geological Society of London in 1933, wherein he discusses comprehensively the evidence bearing on the age of the glacial phase at the beginning of the Gondwana period.[30] Finally a general discussion from the palæontological standpoint of the question of land bridges in Gondwana times has been given by C. Schuchert[31]; while A. L. du Toit, a supporter of the hypothesis of continental drift, has discussed the classification of the sediments of Gondwana times and the question of the boundary between the Carboniferous and the Permian.[32]

I have in these articles made little reference to recent work on the general structure of India, except indirectly in the sections dealing with the Himalaya. Attention, however, may be drawn to two papers which are of importance. The first contains a discussion by Dr. L. L. Fermor on the origin of the Aravalli range.[33] In this it is concluded that there was an original fold-range in pre-Vindhyan times which was largely eroded before the deposition of the Vindhyans (? Cambrian), and that this range was subsequently rejuvenated as a horst bounded by faults in post-Vindhyan times. Thus its present aspect as a mountain range is regarded by Dr. Fermor as younger than had hitherto been thought and not directly connected with the original folding. The second paper is by E. A. Glennie, and deals with the data provided by the geodetic investigations of the Survey of India.[34] This is an illuminating paper, for it marshals the geodetic evidence in such a way as to throw light from a new angle on many problems of Indian geology. And though it seems that there is still a long way to go before the observed facts of geology and the geodetic evidence can be satisfactorily correlated, the paper is one which should be read by everyone taking an intelligent interest in the broader aspects of Indian geology and in general problems of earth history.

In conclusion, it can, I think, be claimed that the advances which have been made in our knowledge of the geology of India during the past decade, which I have attempted to outline in the preceding articles, have been very considerable. If any general conclusion can be drawn from a survey of this work, it is perhaps that recent work has for the most part demonstrated the soundness of the foundations which were laid 60 and 70 years ago by the pioneers of Indian geology, chief among whom were H. B. Medlicott and W. T. Blanford. Much of this early work had a significance which extended beyond the boundaries of India. Whether the same can be said for the more recent work time alone can tell.

Finally, I express my thanks to Dr. Fermor for reading through the whole of these articles, and for offering a number of valuable suggestions.

"The man who makes no mistakes does not usually make anything."—EDWARD J. PHELPS.

[27] *Rec. Geol. Surv. Ind.*, 1922, **54**, 14, *Bull No.* 2, *Geol. Dept., Rewah State*, 'Rewah State Coalfields' 1923, 1-22.

[28] *Rec. Geol. Surv. Ind.*, 1928, **60**, 399.

[29] *Op. cit.*, 307.

[30] *Quarl. Journ. Geol. Soc.*, 1933, **89**, 64.

[31] *Bull. Geol. Soc. Amer.*, 1932, **43**, 875.

[32] *Rept. XVI Intern. Geol. Congr. Washington*, 1933.

[33] *Rec. Geol. Surv. Ind.*, 1930, **62**, 391.

[34] Survey of India, Professional Paper No. 27, 1932.

Obituary.

WE regret to announce the sudden death of Dr. Ganes Prasad, M.A., D.Sc., Hardinge Professor of Higher Mathematics, Calcutta University, on the 9th inst. Dr. Prasad was a prominent educationist, a well-known mathematician and one of the founders of the Agra University.

Letters to the Editor.

The Photo-dissociation of Single Crystals of Potassium and Sodium Nitrates under Polarised Light.

In a previous communication[1] by Mr. Guha and one of us it was suggested that the well-known absorption bands of inorganic nitrates in the ultra-violet, having their long wave-length limits at about 350 $m\mu$ and 230 $m\mu$ respectively, may be attributed to the following photo-dissociations :—

$NO'_3 \rightarrow NO'_2 + O\ (^3P) - 81$ kilocals. (350 $m\mu$)

$NO'_3 \rightarrow NO'_2 + O(^1D_2) - 124$ kilocals. (230 $m\mu$)

The observation with single crystals of KNO_3, NH_4NO_3, $NaNO_3$, etc., in which the NO'_3 ions are all oriented parallel to one another, that both the absorption bands are strongly polarised, the ordinary rays being absorbed much more strongly than the extraordinary rays, was interpreted as indicating a corresponding difference between the photo-dissociative activities of the two rays.

We have recently made some experiments on the photo-dissociation of solid inorganic nitrates, particularly with a view to testing the above conclusions. The following are the main results obtained :—

(1) All the nitrates studied, namely those of K, Na, NH_4, Sr, Ba, Al, Cd and Pb, showed definite dissociation under the action of light (from a quartz mercury lamp) of wave-lengths shorter than about 250 $m\mu$ (region of the stronger absorption band), as tested by the formation of nitrite. The actual long wave-length limit of the photo-active region of the spectrum was not determined.

(2) The dissociation appears to be confined to a thin surface layer of the crystal, about 20μ thick. The absence of permanent dissociation in the interior is attributable to the recombination of the products of dissociation.

(3) Experimenting under linearly polarised light (obtained by passing the light from the arc through a quartz double-image prism), with single crystals of KNO_3, NH_4NO_3 and $NaNO_3$, it was found that the dissociation is much greater when the electric vector of the exciting light is in the plane of the NO'_3 ions (ordinary ray) than when it is along the normal to their planes.

(4) $KClO_3$ crystals also show a similar anisotropic photo-dissociation.

K. S. KRISHNAN.
L. K. NARAYANASWAMY.

210, Bowbazar Street,
Calcutta,
February 25, 1935.

[1] *Curr. Sci.*, 1933, **2**, 476; *Proc. Ind. Acad. Sc.*, 1934, **1**, 242.

Absorption Spectra of Sulphur-Chlorides and -Oxychlorides in the Vapour State.

In continuation of previous work already reported,[1] it was found necessary to study the absorption spectra of the series of compounds— SCl_2, S_2Cl_2, $SOCl_2$ and SO_2Cl_2. This work is now complete and we present a summary of the results obtained.

[1] *Curr. Sci.*, 1934, **2**, 433.

Substance	A		B			C			D		
	a	*b*	*a*	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*
SCl_2	5825	5165 ?	4550	3860	3700	2770	2610	2450	2350	2280	2260
S_2Cl_2						2770	2580	2390			
$SOCl_2$						2900	2450	2400			
SO_2Cl_2									2600—continuous		

a gives the beginning, *b*, the maximum and *c*, the end of absorption in wavelengths (A. U. in air).

The data for the last three substances are in reasonable agreement with those obtained in their liquid states.[2] It is seen that all the first three compounds show an absorption band in region C. In every case the band is very strong. The maximum of the band is not constant but shows definite shift from compound to compound. These and other considerations rule out the apparent possibility of the band being due to a common impurity. On the other hand they indicate that this absorption is to be connected with the common link, *viz.*, the *p-p* linkage between S and Cl, which all these molecules possess. The absorption spectrum of SCl_2 is analogous to that of OCl_2.[3] The slight maximum in the region A at 5165 is doubtful and may after all be fortuitous, due to reflection losses in the intensity of the continuous beam. If this is so, region A is just a continuation of the absorption in region B brought about by increase in pressure.

Very often absorption bands due to SO_2 present themselves in the spectra of all of these molecules but they can be avoided with due precautions. The general appearance of these bands on the plates is not always the same and varies with different pressures of the vapours of the accompanying molecules. Actual measurement, however, proves that these bands are due to SO_2. In particular the band system referred to in our previous communication is now definitely traced by us to SO_2. Details will be published shortly.

R. K. ASUNDI.
R. SAMUEL.

Physics Laboratory,
Muslim University,
Aligarh,
March 13, 1935.

On the Ratio of the Temperature Coefficients of Surface Tension and Density.

"MEASUREMENTS have shown that . . . .there is marked parallelism between the temperature coefficient of surface tension . . . .and the coefficient of expansion. The greater the latter, the greater also is the decrease in surface tension per degree, and the ratio

$$\frac{\text{temperature coefficient (of surface tension)}}{\text{coefficient of expansion}}$$

is approximately the same—between 2 and 3 —for a very large number of liquids."[1] No formal proof of this observation appears to have been put forward so far. A simple proof based on Laplace's theory of Capillarity is therefore given below.

Laplace assumes that the range of molecular forces is the same for all bodies and that at equal distances the force is proportional to the density of the substance, thus implying that the function $\psi(z)$ is the same for all bodies.[2] This hypothesis, though leading to results incompatible with experiments on interfacial tension, can however be assumed to nold for the same liquid at different temperatures. From Laplace's theory we obtain for the surface tension, T, of a liquid that

$$T = \tfrac{1}{2}\sigma^2 \int_0^\infty z\psi(z)dz \quad .. \qquad .. \quad (a)$$

where σ is the density of the liquid. Assuming, by our hypothesis, that $\int_0^\infty z\psi(z)dz$ does not vary with temperature, θ, we get

$$\frac{dT}{d\theta} = \sigma \frac{d\sigma}{d\theta}\int_0^\infty z\psi(z)dz \quad .. \qquad .. \quad (b)$$

Dividing (b) by (a),

$$\frac{\frac{1}{T}\frac{dT}{d\theta}}{\frac{1}{\sigma}\frac{d\sigma}{d\theta}} = 2$$

which proves that the required ratio is equal to 2, because $\frac{1}{\sigma}\frac{d\sigma}{d\theta} = -\frac{1}{v}\frac{dv}{d\theta}$, where v is the volume of the liquid. This ratio obtained by Laplace's theory is in close agreement with the experimental observation that it lies between 2 and 3.

The fact that the observed value is always greater than 2 is significant and can be accounted for by assuming that, $\psi(z)$ remaining the same, the range of molecular attraction, c, varies with temperature. It follows that

$$\frac{dT}{d\theta} = \sigma \frac{d\sigma}{d\theta}\int_0^c z\psi(z)dz + \tfrac{1}{2}\sigma^2 \int_c^{c+\frac{dc}{d\theta}d\theta} z\psi(z)dz$$

[2] *Zeit fur Physikalische Chemie* (B), 1931, **14**, 219.
[3] *Ibid.*, 1931, **15**, 127.

[1] *Surface Tension and Surface Energy* by R. S. Willows and E. Hatschek, 1915, p. 7.
[2] *Vide Properties of Matter* by J. H. Poynting and J. J. Thomson, 1922, p. 179.

because

$$\int_0^{c+\frac{dc}{d\theta}d\theta} z\psi(z)dz - \int_0^{c} z\psi(z)dz = \int_c^{c+\frac{dc}{d\theta}d\theta} z\psi(z)dz.$$

Hence

$$\frac{\frac{1}{T}\frac{dT}{d\theta}}{\frac{1}{\sigma}\frac{d\sigma}{d\theta}} = 2\left[1+\tfrac{1}{2}\frac{1}{\frac{1}{\sigma}\frac{d\sigma}{d\theta}}\frac{\int_c^{c+\frac{dc}{d\theta}d\theta} z\psi(z)dz}{\int_0^{c} z\psi(z)dz}\right]$$

$$= 2\,(1+\epsilon)$$

where, according to the experimental results, $0 < \epsilon < \frac{1}{2}$. When $\epsilon = 0$, it means that $\int_c^{c+\frac{dc}{d\theta}d\theta} z\psi(z)dz = 0$, and hence $\frac{dc}{d\theta} = 0$, or there is no variation of c with temperature. But when $\epsilon = \frac{1}{2}$,

$$\frac{\int_c^{c+\frac{dc}{d\theta}d\theta} z\psi(z)dz}{\int_0^{c} z\psi(z)dz} = \frac{1}{\sigma}\frac{d\sigma}{d\theta}.$$

L. SIBAIYA.

Department of Physics,
Central College, Bangalore,
February 26, 1935.

Anomalous Magnetic Rotation of Uranyl Nitrate.

IN continuation of the work on magneto-optical rotation[1,2] we have made at the suggestion of Prof. S. S. Bhatnagar, some observations on this property in the case of uranium salts. It has been observed that uranyl nitrate shows a negative Faraday effect. The molecular magnetic rotation value is 5·2, assuming that of water to be 1, and it is constant over a wide range of concentration.

All known substances showing a negative Faraday effect with the exception of titanium chloride are paramagnetic (though the converse is not true). The result obtained is of particular significance in view of the fact that this is another substance which in spite of being diamagnetic like titanium chloride shows negative rotation. In the formula of Ladenberg[3] and others[4] for the Faraday effect there exist two terms, one which covers the case of diamagnetic part of the molecule and the other the paramagnetic part. This anomalous effect may be attributed to the influence exercised by the paramagnetic term of these formulæ. Further work is in progress and the results will be communicated shortly.

P. L. KAPUR.
MULK RAJ VERMA.

University Chemical Laboratories,
University of the Punjab,
Lahore.

The Optical Rotatory Dispersion of α- and β-Pinenes in the Ultra-Violet.

IN our previous work[5] it was found that the optical rotatory dispersion of α-pinene till = 3000Å could be satisfactorily expressed by a single term Drude's equation of the form $[\alpha] = \frac{k}{\lambda^2 - \lambda_0^2}$ the value of the characteristic frequency λ_0 being 1900Å. This value is in satisfactory agreement with absorption spectrum measurements of α-pinene in the vapour state.[6] Our measurements on the rotatory dispersion of β-pinene till $\lambda = 2784$Å, which will be published shortly, also indicate the absence of any maximum on the positive side of its rotatory dispersion curve. These observations are in contradiction with those reported by Servant[7] according to whom both α- and β-pinenes in dilute alcoholic solutions attain maximum values in the region $\lambda = 2800$Å. Our measurements had been made on the pure liquids without the use of any solvent, but since a solvent effect of such magnitude seemed improbable in these cases we measured the rotatory dispersion in alcoholic solutions at approximately the same concentration as was used by Servant. In both cases our previous observations have been confirmed because no anomaly has been noticed till the limit of

[1] Bhatnagar, Mathur and Jain, *Ind. J. Phys.*, 1930, **4**, 503.

[2] Bhatnagar and Kapur, *J. Ind. Chem. Soc.*, 1934, **9**, 767.

[3] Ladenberg, *Zeit. f. Phys.*, 1927, **46**, 168.

[4] Rosenfeld, *Zeit. f. Phys.*, 1930, **57**, 835.

[5] *J. A. C. S.*, 1935, **57**, 334.

[6] Stark, Steubing, Einklaar and Lipp, *Jahrb. Radio activietat*, 1913, **10**, 139.

[7] Servant, *Compt. Rend.*, 1932, **194**, 368.

transmission λ = about 2600Å. The absorption of β-pinene which had not previously been measured was found by a Hilger's "Spekker" spectrophotometer to be negligible till $\lambda = 2350$Å. Moreover, if it is postulated that the anomalous rotatory dispersion of β-pinene in the visible spectrum is a superposition effect of two rotations of opposite sign and unequal dispersion, it will be very difficult to explain the second anomaly at $\lambda = 2800$Å in the absence of an absorption band in that region. These observations coupled with the fact that the specific rotations, so far as they can be calculated from the data given by Servant in his paper, are considerably below those usually ascribed to α- and β-pinenes in the literature would seem to suggest that the anomaly at $\lambda = 2800$Å is not characteristic of the pure substances.

R. PADMANABHAN.
S. K. KULKARNI JATKAR.

Indian Institute of Science,
Bangalore,
February 13, 1935.

Pasteur's Principle of Molecular Dissymmetry: The *dextro-* and *lævo-*Camphoric Acids.

ACCORDING to Pasteur's principle of molecular dissymmetry, enantiomorphous molecular configurations must possess the same total energy. They must show similar mechanical stability and therefore have an equal chance of being produced. They must also possess identical scalar properties such as density, viscosity, solubility, refraction, dispersion, and Raman frequencies. But they must differ in those physical properties which are of the directional (vectorial) nature, such as, for example, direction of rotation of the plane of polarisation of polarised light, unsymmetrical distribution of the hemihedral facets in the crystal forms and also in the enantiomorphous distribution of pyro- and piezo-electrical polarity. The magnitude of these vectorial properties is, however, identical for the enantiomorphous forms. These results follow from classical mechanics. On the other hand, according to wave-mechanics,[1] the *dextro-* and *lævo-*form of a compound differ in energy and rotatory power although perhaps only to a very slight extent. The same view was also expressed by Campbell[2] based on rather arbitrary assumptions regarding association in racemates and optically active compounds.

In support of the latter view, A. N. Campbell[3] alleges to have produced evidence that the *d-* and *l-*camphoric acids are not identical in their physical properties. In anticipating the criticism which might be brought forward that his materials were not pure, he has taken elaborate pains in giving a detailed statement of the methods of preparation and purification of the two camphoric acids. But Pasteur's law of molecular dissymmetry is too fundamental to be dismissed by a few isolated observations. It seems impossible that the *d-* and *l-*forms of a compound could be other than an object and its non-superposable exact mirror image, agreeing precisely in every detail of structure and of properties except those of a vectorial nature which differ in sign but otherwise are identical in the numerical magnitude in all cases. Moreover it should be borne in mind that the wave-mechanics of rotatory polarisation is, at present, in a rather unsatisfactory condition.

With the object of testing the validity of Pasteur's law as regards the equality in the numerical value of the rotatory power of the opposite active forms, an extended series of investigations on the rotatory dispersion of the enantiomorphous forms was undertaken in this laboratory since 1926. The results of this work, which have gone to confirm Pasteur's law in an unequivocal manner, have been reported in several communications.[4]

In order to remove the above-mentioned discrepancy in the equality of the value of the rotatory power of *dextro-* and *lævo-*camphoric acids, the writer has re-examined their rotatory dispersions. Particular care was taken in following Campbell's methods of preparation and purification of these two acids for obvious reasons. Whereas Campbell found that the rotatory powers of *lævo-*form were systematically lower than those of the *dextro-* for three wave-lengths

[1] G. Temple, *Trans. Faraday Soc.*, 1930, **26**, 272.

[2] *Nature*, 1929, **124**, 792.

[3] *J. Amer. Chem. Soc.*, 1931, **53**, 1661.

[4] B. K. Singh and B. Bhaduri, *J. Indian Chem. Soc.*, 1930, **7**, 54, 771; *Trans. Faraday Soc.*, 1930, **26**, 347; B. K. Singh, H. P. Basu-Mallik and B. Bhaduri, *J. Indian Chem. Soc.*, 1931, **8**, 95; B.K. Singh, B. Bhaduri and T. P. Barat, *ibid.*, 1931, **8**, 915.

investigated, it is now found that the rotatory dispersions of *dextro-* and *lævo*-forms of camphoric acid are identical for 10 wavelengths (λ = 4358 to 6709). These results are given in Table I from which it can be seen that the values of the rotatory power of *dextro-* and *lævo*-forms are identical within the experimental error. A more detailed account of this work will appear elsewhere.

TABLE I.

Specific Rotation of d- *and* l-*Camphoric Acids in Ethyl Alcohol at 35°C.*
(Length of tube—2 dcm.)

Line		[α]									
	Form ..	*dextro*	*lævo*	*dextro*	*lævo*	*dextro*	*lævo*	*dextro*	*lævo*	*dextro*	*lævo*
	Conc... g/100 c.c.	1·2533	1·2526	3·2467	3·2473	5·2530	5·2500	7·2500	7·2507	9·2500	9·2480
Hg_{4358} ..	..	+98·94°	−97·40°	+96·15°	−95·62°	+94·41°	−94·87°	+94·37°	−94·76°	+93·30°	..
Cd_{5086} ..	..	70·61	70·70	66·66	66·99	66·24	65·92	66·00	65·93	65·21	−65·23°
Ag_{5209} ..	..	65·83	66·26	63·46	63·33	62·63	62·86	62·40	62·50	62·03	61·99
Hg_{5461} ..	..	59·44	59·08	56·84	56·83	56·35	56·19	56·21	56·12	55·40	55·46
Ag_{5469} ..	..	59·04	59·08	56·84	56·82	56·15	56·19	55·86	55·78	55·49	55·41
Hg_{5780} ..	..	51·46	51·89	49·90	49·89	49·68	49·71	49·38	49·38	48·91	49·08
Na_{5892} ..	..	49·87	50·30	48·07	48·20	47·79	47·80	47·44	47·38	46·95	47·02
Li_{6104} ..	..	45·47	44·71	44·51	44·66	43·97	44·15	43·79	43·65	43·71	43·78
Cd_{6438} ..	..	41·09	41·52	39·67	39·42	39·41	39·44	39·03	39·24	39·06	38·97
Li_{6709} ..	..	37·50	36·32	36·22	36·19	35·98	35·82	35·72	35·66	35·62	35·56

The Chemical Laboratory,
Ravenshaw College, Cuttack,
March 8, 1935.

BAWA KARTAR SINGH.

The Diamagnetic Susceptibility of Water Polymers.

DETERMINATION of the magnetic susceptibility of water at different temperatures by several workers has established that the temperature co-efficient of susceptibility of water is positive; there is, however, not much numerical agreement between the actual values deduced for this co-efficient. The results of Cabrera and Fahlenbrach[1] seem to indicate that for water between 0°C. and 120°C., the temperature co-efficient is constant and has a value equal to $+1{\cdot}15 \times 10^{-4}$. Assuming the values for the relative abundance of the different polymers in water at various temperatures given by Ramakrishna Rao[2] from Raman spectrum data, we can compute the susceptibilities of (H_2O), $(H_2O)_2$ and $(H_2O)_3$:

$$\chi_{(H_2O)} = 1{\cdot}0744\chi_{20} = -0{\cdot}7755 \times 10^{-6}$$
$$\chi_{(H_2O)_2} = 1{\cdot}0006\chi_{20} = -0{\cdot}7222 \times 10^{-6}$$
$$\chi_{(H_2O)_3} = 0{\cdot}9716\chi_{20} = -0{\cdot}7013 \times 10^{-6}$$

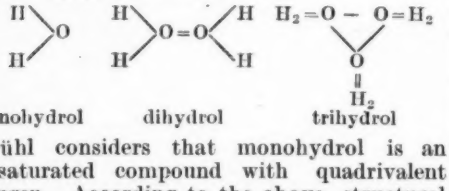
A value of $-0{\cdot}7218 \times 10^{-6}$ has been assumed for χ_{20} from the experimental values of Auer. The above results for the three hydrols have been calculated by assuming the constitution of water at 4°C., 38°C. and 98°C. The calculated susceptibility of water at 0°C. by using these values for mono-, di- and trihydrols is $-0{\cdot}7199 \times 10^{-6}$, while the observed value is $-0{\cdot}7201 \times 10^{-6}$. This is in itself a striking agreement. Using Ramakrishna Rao's data for ice, the computed value for the susceptibility of ice works out to be $-0{\cdot}7080 \times 10^{-6}$. If it is assumed that water vapour consists mainly of monohydrols, its specific susceptibility will be nearly $-0{\cdot}7755 \times 10^{-6}$. But "the vapour density of steam is rather too great for the molecular formula H_2O and much too small for $(H_2O)_2$. It is therefore assumed that steam contains a mixture of H_2O with a few $(H_2O)_2$ molecules, and that the equilibrium condition for water vapour, $(H_2O)_2 \rightleftharpoons 2(H_2O)$, corresponds with 91 per cent. of H_2O molecules in the vicinity of 100°C."[3] Computed

[1] *Zeits. f. Physik*, 1933, **82**, 759-764.
[2] *Proc. Roy. Soc.*, 1934, **145**, 506.
[3] *Modern Inorganic Chemistry* by J. W. Mellor, 1922, 153-154.

on the basis of these assumptions, the susceptibility of steam at 100°C. is $-0{\cdot}7674 \times 10^{-6}$. The experimental results of Auer[4] show on the other hand that the temperature co-efficient of susceptibility of water is not constant and is itself a function of temperature.[5] A recalculation of the above values is not possible on account of the insufficiency of Auer's data.

The fact that the values of susceptibility of H_2O, $(H_2O)_2$ and $(H_2O)_3$ should go on diminishing seems to be in itself significant. It has been shown by Ramachandra Rao and Varadachari[6] that the various hydrates of H_2SO_4, like $H_2SO_4 . H_2O$, etc., show a decrease in diamagnetic susceptibility as computed from the additive law. Thus if SO_4^{--} ion is substituted by O^{--} ion in H_2SO_4 hydrates, we obtain the water polymers; the decrease in diamagnetic susceptibility resulting from polymerisation in water is seen to be consistent with the observations on the hydrates of sulphuric acid. The percentage deviation from the mixture law is about 10% in $(H_2O)_3$ and about 7% in $(H_2O)_2$; the order of deviation in sulphuric acid hydrates varies from 3 to 4 per cent.

From measurements on the variation of density of water with temperature, Sutherland[7] has concluded that water consists mainly of $(H_2O)_2$ molecules, whereas $(H_2O)_3$ molecules predominate in ice. He has suggested for these molecular aggregates the following graphic formulæ:



monohydrol dihydrol trihydrol

Brühl considers that monohydrol is an unsaturated compound with quadrivalent oxygen. According to the above structural formulæ, it is clear that while the oxygen atom is divalent in monohydrol, it becomes quadrivalent in di- and tri-hydrols.[8] The change in valency is attended by a corresponding change in diamagnetism and we therefore observe that in passing from mono- to di-hydrol the deviation from the additive law is more than 7%. But as we proceed from dihydrol to trihydrol where there is no change of valency, the deviation is less than 3%.

From the values obtained for the mono-, di- and tri-hydrols it is seen that each particular type is by itself diamagnetic. Since diamagnetism shows no variation with temperature and the additive law holds in general for diamagnetic liquid mixtures, we cannot possibly ascribe the temperature variation of susceptibility of water to any other cause except the variation in the relative abundance of the polymers at different temperatures, each polymer being assumed to have a particular value of diamagnetic susceptibility which does not vary with temperature.

I thank Mr. B. Nagesha Rao, Post-graduate student, for checking my calculations.

L. SIBAIYA.

Department of Physics,
Central College,
Bangalore,
March 4, 1935.

[4] *Ann. d. Physik*, 1933, **18**, 593-612.

[5] Auer's values of the temperatures co-efficient of susceptibility (α) at various temperatures (θ°C) can be satisfactorily represented by the empirical formula: $\alpha \times 10^4 = 0{\cdot}35 + \frac{16{\cdot}4}{3{\cdot}43+\theta}$

[6] *Curr. Sci.*, 1934, **3**, 250.

[7] *Phil. Mag.*, 1900, **50**, 460.

[8] It is assumed by some that the oxygen atom in carbon monoxide is also quadrivalent, *i.e.*, C≡O.

Free Phenolic Group in Lignin (Evidence from Action of Chlorine Dioxide on Aromatic and Aliphatic Compounds).

THE behaviour of a few organic compounds with one or more free phenolic OH, towards chlorine dioxide (to give simple aliphatic acids) has been utilised by Schmidt and co-workers[1] as well as by Fuchs and Honsig[2] as an argument for assuming the presence of a free phenolic OH group in lignin which behaves in a similar way.

The action of ClO_2 on 20 aromatic compounds with free phenolic OH has been tried and it has been found that all of them were readily decomposed. But when the phenolic groups were protected either by methylation or acetylation, the resulting products also reacted with ClO_2 but less readily. Acetylated or methylated lignin behaves similarly. Aliphatic OH in the side-chain is also susceptible to the oxidising action of ClO_2 and the action is less vigorous when it is methylated or acetylated.

[1] *Ber.*, 1925, **58**, 1394.

[2] *Ber.*, 1926, **59**, 2850.

As lignin contains beyond doubt, more than one methoxy group attached to the benzene ring, it is obvious that the fact that it is acted upon by ClO_2 does not in any way prove the existence of aromatic OH in the molecule.

It has also been observed that the only substituent that makes the benzene compounds stable towards ClO_2, is the carboxyl; all others are attacked more or less easily. Even toluene and xylenes are oxidised by this reagent. The di-oxymethylene group, however, has been found to be quite resistant towards ClO_2.

PULIN BEHARI SARKAR.
Department of Chemistry,
Dacca University,
January 29, 1935.

Fumeless Digestion of Nitrogen.

ESTIMATION of nitrogen is perhaps the most important item of procedure in modern chemical analysis, over a million determinations being annually carried out by those engaged in scientific research alone. The estimations are usually carried out according to one or the other of the several modifications of the Kjeldahl method,[1] and involve prolonged digestion with concentrated sulphuric acid—an operation which is attended by emission of objectionable acid fumes. Some recent workers[2,3] have suggested that the residue after wet combustion of carbon can be distilled as such for nitrogen, but such a procedure, especially in the case of soils and other biological materials, leads invariably to retention of nitrogen in the digest, and consequently, low and inconsistent estimates being obtained.

A systematic enquiry into the various factors relating to the digestion has shown the following:—(*a*) the conversion of organic nitrogen into ammonia proceeds more rapidly in presence of small amounts of water combined with an oxidising agent (preferably chromic acid) than with concentrated sulphuric acid alone. In the case of soils, a mixture of sulphuric acid and water in the proportion of 2 to 1 yields the best results, the entire digestion being complete in 30 mins. During digestion, the proportion of acid to water has to be maintained constant, so it would be necessary to fit the digesting flask with an air- or water-cooled condenser. (*b*) The digesting mixture requires only a low flame and does not bump, so the long-necked (Kjeldahl) flask generally used for the purpose can be dispensed with. In fact, both the digestion and the distillation can be conducted in the same flask. (*c*) The minute quantities of nitrogen still retained in the digest can be easily released by addition of small amounts of zinc just prior to distillation with alkali. Metallic aluminium or Devarda's alloy can also be used for the purpose, but their action is a little too vigorous, and causes alkali spray to pass over into the distillate. (*d*) In the case of materials containing chlorides, it would be necessary to add a small quantity of mercuric or silver sulphate to the digesting mixture, for, otherwise, free chlorine will be formed and nitrogen will be lost in the elementary form. If the substance (*e.g.*, soil) contains nitrate, the latter should first be extracted with water preferably in presence of a suitable flocculant such as calcium sulphate. The residue is digested in the usual way and the digest, together with the extract containing nitrate, distilled with zinc and alkali, in the manner outlined above.

A simple method embodying the above principles has been developed and applied successfully to the estimation of nitrogen in soils. The procedure is also being extended to other biological materials and to nitrogenous substances in general. Attempts are also being made to combine the above method with that for the estimation of carbon[4] so that both the determinations can be carried out on the same sample.

Y. V. NARAYANAYYA.
V. SUBRAHMANYAN.
Department of Biochemistry,
Indian Institute of Science,
Bangalore,
March 12, 1935.

[1] Kjeldahl, *Z. anal. Chem.*, 1883, **22**, 366.

[2] Anderson and Schutte, *J. Biol. Chem.*, 1924, **61**, 57.

[3] Brown, *Ind. Eng. Chem.*, 1927, **19**, 629.

The Occurrence of *Choanephora cucurbitarum* (B. & Rav.) Thaxter on *Cassia Tora* Linn.

IN September 1934 our attention was drawn by Prof. B. Sahni to a dead shoot of *Cassia Tora* infected by the white mycelial hyphæ

[4] Subrahmanyan, Narayanayya and Bhagvat, *J. Indian Inst. Sci.*, 1934, **17A**, 197.

of *Choanephora cucurbitarum*. Both sporangia and conidial heads of the usual type were noticed. A large number of atypical triangular sporangiospores were found which bore clusters of very fine radiating appendages at the ends. No zygospore stage was found.

This species has been mentioned to occur on the fading flowers of quite unrelated plants such as *Hibiscus*, *Cucumis*, *Gossypium*, *Capsicum* and a number of Cucurbitaceous plants.*‡

The fungus has been said to be a parasite. But our preliminary observations tend to show that it can also lead a vigorous saprophytic life. An examination of a number of healthy plants of *Cassia Tora* infected with *C. cucurbitarum* did not reveal the existence of the parasite in a number of plants examined out of a great forest of them. But the fallen twigs and leaves where there was plenty of moisture were mostly found infected with the fungus. This fact has raised doubts in our minds whether it is an obligate parasite at all. A single inoculation on the stem and leaves of the vigorous plants did not give any satisfactory results. Inoculation experiments will be repeated in the next rainy season when the weather conditions are favourable.

H. P. CHOWDHURY.
R. S. MATHUR.

Department of Botany,
Lucknow University,
February 25, 1935.

Observations on the Systematic Position of *Ficus Krishnæ* growing at the Royal Botanic Garden, Calcutta.

ONE of the trees of *Ficus Krishnæ* C. de C., growing for more than thirty-two years in the nursery of the Royal Botanic Garden, Calcutta, developed what may be called a bud mutation[1] on one of its branches—about five years ago—as shown in Fig. 1.

The broad flat leaves like the leaves of *Ficus bengalensis* are the mutated leaves. The rest are all cup-shaped normal leaves of *Ficus Krishnæ*.

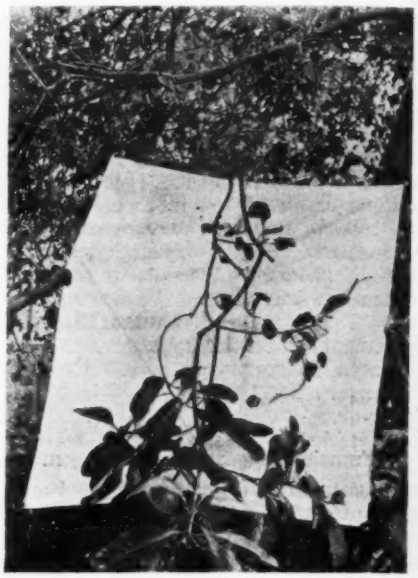


Fig. 1.

Mutated branch of *Ficus Krishnæ*.

Germination experiment from the seeds of *Ficus Krishnæ* shows only about 10 per cent. breeding true, the rest, about 90 per cent., are of the type of *Ficus bengalensis* L. But when *Ficus Krishnæ* is propagated from *goolies* or cuttings of *Ficus Krishnæ* the daughter plant nearly always bears hypoascidi-form leaves of the mother plant. This *Ficus Krishnæ* which has exhibited bud mutation was introduced during the last decade of the nineteenth century in the Royal Botanic Garden from cuttings secured from another plant of *Ficus Krishnæ* growing in a private garden in the neighbourhood of the Calcutta Botanic Gardens. The plant was named by C. de Candolle in 1901 as a separate species. The Indian view is that it is a modified garden variety of *Ficus bengalensis*. It is from this garden that cuttings were sent to C. de Candolle at Geneva and to Kew—sometime in 1900-1901. The plant was successfully grown in the tropical house at the Kew Garden which produced receptacle for the first time in 1905.[2] Prof. Hans Molisch who happened to pay a visit to the Calcutta Botanic Garden

* H. M. Fitzpatrick, *The Lower Phycomycetes*, 1930, pp. 259, 262.

‡ Dastur, J. F., *Choanephora cucurbitarum* (B. & Rav.) Thaxter on chillies (*Capsicum* spp.). *Ann. Bot.*, 1920, **34**, 599.

[1] Biswas, K., "Bud Mutation," *Nature*, 1932, **130**, 780.

[2] Prain, D., *Curtis' Botanical Magazine*, 1906, **2**, Tab. 8092.

in 1929[3] considers *Ficus Krishnæ* a mutation of *Ficus bengalensis*. Further he remarks that if C. de Candolle would have seen this mutation on this tree (*Ficus Krishnæ*) at the Royal Botanic Garden, Calcutta, he would not have taken it as a separate species. Penzig mentions that some authors consider these beaker-like "Hypoascidien" leaves abnormal forms.[4] Germination of the seeds and floral structures of *Ficus bengalensis* and *Ficus Krishnæ* hardly exhibit any variation between the two.

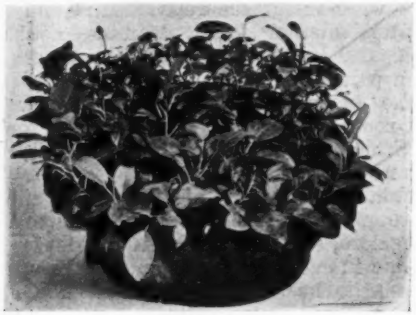


Fig. 2.

Seedlings of *Ficus Krishnæ* developing like the seedlings of *Ficus bengalensis*.

The difficulty is, as Sir David Prain notes, that we do not know the history of the parent tree in the neighbourhood of the Royal Botanic Garden—from which the plant was cultivated in this garden. This problem of mutation, therefore, may be solved by cytogenetical investigation. Purely cytological characters, as the late Prof. S. R. Kashyap's preliminary examination proved, may not be quite definite to solve the problem of such reversion.[5] *Ficus Krishnæ* belongs to the section *Urostigma*. The writer considers, on the ground stated above, that this *Ficus Krishnæ* is a horticultural variety of *Ficus bengalensis*. The anatomical characters also exhibit normal fusion of tissues leading on to the formation of "Hypoascidien" leaves.

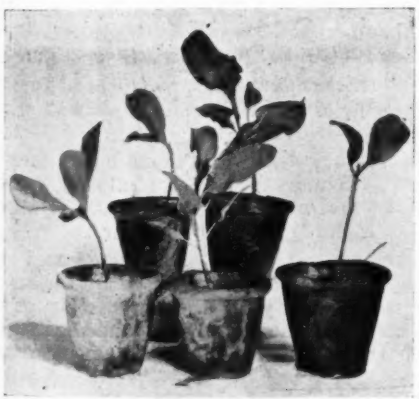


Fig. 3.

Young plants of *Ficus Krishnæ* grown from gooties.

[3] Molisch, H., *Als Naturforscher in Indien*, 1930.
[4] Penzig, O., *Pflanzen-teratologie*, 1922, 3.

K. BISWAS.

Herbarium,
Royal Botanic Garden,
Calcutta,
February 20, 1935.

The Morphology of the Bulbils of *Globba* sp.

THE morphological nature of the bulbils of *Globba* has been investigated by W. D. van Leeuwen and others. It is generally believed that among the bulbils of *Globba* certain species are found in which storage of food material takes place in root-tubers while in some cases there are storage rhizomes and the roots are not tuberous. The results of investigations on the morphology of the bulbils of *Globba* sp. carried out by me in this laboratory, however, strongly suggest that these appear to be highly metamorphosed fruit bodies. The following points observed support the above view:—

(1) Occurrence and position in the inflorescence. (2) Relative position of the bud and the storage tissue (*cf.* similar monocot seed). (3) Presence of coatings round the storage tissue. (4) External appearance similar to a normally developed ovary (fruit). (5) Attainment of more or less the size by all, when mature. (6) Growth while attached to the inflorescence in the manner of a viviparous fruit.

The results of detailed investigations will be communicated in a separate paper.

S. GHOSE.

St. Xavier's College,
30, Park Street,
Calcutta,
February 15, 1935.

[5] King, G., *Ann. of the R. B. Garden, Calcutta*, 1888, 1.

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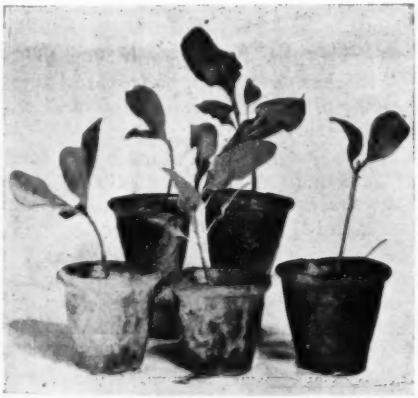

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S. GHOSE.

St. Xavier's College,
30, Park Street,
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February 15, 1935.

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Specificity of Parasitism by *Eublemma amabilis*.

MAHDIHASSAN[1] states that Imms and Chatterjee[2] suspected *E. tachardiæ* to be a beneficial insect and that he himself definitely proved it to be a parasite of *Eublemma amabilis* caterpillars.

The Indian Lac Research Institute began its work on the lac insect and on its parasites and predators in 1926 and during the last eight years many miles of lac encrustation and many thousands of *E. amabilis* larvæ have been examined in the Entomological Department. Our investigations have proved *E. tachardiæ* to be a parasite of the lac insect *L. lacca* and in no instance has this species been found to be parasitic on *E. amabilis*. This view was first put forward by Gupta, Negi and Misra[3] in 1929 who also record *Machærota* sp. as an alternative host: in the *Institute Annual Report* for 1928-29 *E. tachardiæ* is noted as a hyperparasite of *Bracon tachardiæ* which is further confirmed by Glover[4,5] who states that *E. tachardiæ* is also parasitic on *Machærota planitiæ* and hyperparasitic on *Apanteles tachardiæ*. Gupta and Negi[6] reconfirm these observations and add a further alternative host in *Holcocera pulverea*, a lac predator (Misra and Gupta[7] in their paper on this predator quote a single instance only of parasitism of *H. pulverea* by *E. tachardiæ*) and record it also as a hyperparasite of the two lac parasites *Tachardiæphagus tachardiæ* and *Erencyrtus dewitzi*.

In addition, Misra, Negi and Gupta[8] in their paper on *E. amabilis* make no reference to *E. tachardiæ* as a parasite of this predator.

E. tachardiæ as previously stated is hyperparasitic on *Microbracon tachardiæ*, a parasite of *Eublemma amabilis* and we have frequently bred *E. tachardiæ* on *Microbracon tachardiæ* in the laboratory. In this connection, Gupta and Negi[6] state "The *Chalcid B. annulicaudis* is primarily an endoparasite of the lac insect, and an ectoparasite of the full-fed larvæ, pre-pupæ and early pupæ of *B. tachardiæ* a parasite (of) *E. amabilis* larva. The *Chalcid* oviposits on the stages of *B. tachardiæ* only if covered with a cocoon."

Gernet's finding of E. *amabilis* and *E. tachardiæ* closely associated in dried stick lac in 1863 in Russia, which Mahdihassan quotes in his letter as an indirect support for his theory that *E. tachardiæ* is a parasite of *E. amabilis*, is of course equally in accordance with their true relationship, and one wonders whether Mahdihassan may not have been misled into mistaking a hyperparasite for a parasite.

The "glaring statement" made by Glover[4,5] and repeated by Glover[9] of "having found it (*E. tachardiæ*) inimical to lac itself" is in fact no more than the truth.

Mahdihassan, to use his own words, after a thorough survey of the *Coccid* fauna of Bangalore, states: "There is no danger to the lac insect in its common enemies having alternative hosts....for such an enquiry.... gave at every step a negative result ....and (led) to specificity of parasiticism" and he criticises Glover[5] whom he quotes, "Several (lac parasites) are suspected of parasitising also insects other than lac .... the alternative host forms a convenient breeding ground for the parasites." Further research has however fully justified Glover's statement, the following being concrete examples:—

Eupelmus tachardiæ, parasitic on *Laccifer lacca*, alternative host *Machærota planitiæ*—Gupta, Negi, Misra[3] and Glover[4].

Tetrastichus purpureus, parasitic on *Laccifer lacca*, alternative host *Aspidiotus orientalis*—Glover.[10]

Marietta javensis Syn. (*Microterys hautfeulli* Mahd?)	Parasitic on *Laccifer lacca*, alternative host *Aspidiotus orientalis* —Glover.[9]

The generic name *Lakshadia* used by Mahdihassan is not recognised by Chamberlin[11] an authority on the *Lacciferidæ* or lac insects, and should be abandoned in keeping with the rules of zoological nomenclature;

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[1] Mahdihassan, *Curr. Sci.*, 1934, **3**, 260.

[2] Imms, A. D., Chatterjee, N. C., *Ind. For. Mem.*, 1915, **3**, 1.

[3] Gupta, S. N., Negi, P. S., and Misra, M. P., *Proc. Ind. Sci. Cong.*, 1929.

[4] Glover, P. M., *Bull. Ent. Res.*, 1930, No. 21, 3.

[5] Glover, P. M., *A Practical Manual of Lac, Cultivation*, Calcutta, 1931.

[6] Gupta, S. N., and Negi, P. S., *Proc. Ind. Sci. Cong.*, 1933.

[7] Misra, M. P., and Gupta, S. N., *Ind. J. Agric. Sci.*, 1934, **4**.

[8] Misra, M. P., Negi, P. S., and Gupta, S. N., *J. Bombay Nat. Hist. Soc.* 1930.

[9] Glover, M. P., *Ind. Lac. Res. Inst. Bull.*, 1934, No. 21.

[10] Glover, P. M., *Ind. Lac Res. Inst. Bull.*, 1933, No. 16.

[11] Chamberlin, J. C., *Bull. Ent. Res.*, 1925, No. 16.

of *Laccifer mysorensis* (Mahdihassan's *Lakshadia mysorensis*) he says, "It seems possible that this form is racially or subspecifically distinct from *lacca*."

The latter part of Mahdihassan's letter indicates that *E. amabilis* is monophagus or at least confined to species of the Genus *Laccifer*. The behaviour of females of monophagus insects of ovipositing only on the host on which the progeny can feed is too well known to merit his further comment.

In examining lac samples at this Institute, not a single one has been found free from that attack of *E. amabilis*, the degree of infestation has of course varied considerably. The liability of lac to attack by this predator does not, according to our experience, depend exclusively on the host plant, being influenced by a considerable range of factors, and it is unlikely that use of a "catch" crop, as Mahdihassan suggests, would be of any great value as a control, at any rate in the important lac growing areas.

P. M. GLOVER.
P. S. NEGI.
Indian Lac Research Institute,
Namkum, Ranchi, Bihar and Orissa,
January, 1935.

Enteropneusta from Krusadai Island.

IN his note on "Enteropneusta from Krusadai Island,"[1] Prof. C. R. Narayana Rao stated:—"S. G. M. Ramanujam has also taken specimens from the same area but it is rather surprising that our collections do not include any of the specimens represented in Dr. Ramanujam's, which does not possess a single form contained in our material. But still both parties were investigating the same area and this rather curious phenomenon of distribution is worth carefully looking into." Since this note was published, I have had an opportunity of visiting the area again and was able to obtain the forms contained in Prof. Narayana Rao's material. My first collection of Balanoglossids was made in September 1930 in the sandy areas of the Porites' and Watchman's Bay. We concentrated at that time on the Northern shores of the Island, facing Mandapam. It was then that the specimens were obtained which Prof. Narayana Rao has kindly identified as *Ptychodera minuta* and *Glandiceps hacksi* and which are not represented in his collections from the Krusadai Island. These forms were by no means abundant and obtained while searching for polychæte worms.

In our visit last October-November, we worked on the Southern side of the Island between the Sandy and Bushy points and were agreeably surprised to find large forms of Balanoglossids which were species of *Chlamydothorax*. Presumably all of Prof. Narayana Rao's material came from this region. A whole bed of sand in this area consisted practically of Balanoglossids and, as it were, one could collect half a dozen specimens in a square foot of area, so that this area has been designated the Balanoglossus Area.

Last January, another party from the Department collected in the same area and the forms, though of the same species, were much bigger and better developed, indicating growth.

It is then evident that the forms on the two shores of the Island differ and, as Prof. Narayana Rao has remarked "this rather curious phenomenon of distribution is worth looking into". Much to our regret, it was not possible owing to high tides to collect on the northern shores during our recent visits to the Island.

S. G. MANAVALA RAMANUJAM.
Department of Zoology,
Presidency College,
Madras,
March, 1935.

[1] *Curr. Sci.*, August 1934, **3**, 70.

Occurrence of the Pelagic Gastropod *Recluzia* (Petit) in Madras.

OF the pelagic Gastropoda *Ianthinide* show that peculiar adaptation of secreting a float which keeps the animal to the surface. In *Ianthina*, the shell is violet-coloured and delicate, and the float is clean-looking.

In a recent trip to Pulicat about 30 miles from Madras, on the 18th and 19th January last, three specimens of a Gastropod were obtained which showed a float of the same nature as that of *Ianthina* and to which on the under side crowded rows of eggs were attached. The shell is rather brownish, dark and light shades alternating, comparatively thick and the spire rather high, as compared to that of *Ianthina*. The float is somewhat muddy-looking. This latter appearance may partly be due to the rows of brown eggs attached on the under surface. The specimens tally with the figure and general description of *Recluzia* given in

Cheno's *Manual de Conchyliologie*, Tome I, p. 119, 1859.

The occurrence of *Recluzia*, so far as I am able to ascertain, has not been recorded hitherto on Indian shores.

A specimen was also obtained from the Madras shore, opposite the Fort, on 7th February by a post-graduate student of this Department.

S. G. MANAVALA RAMANUJAM.
Department of Zoology,
Presidency College,
Madras,
February 28, 1935.

The Age of the Deccan Traps.

I HAVE read with considerable interest the paper "The Deccan Traps: Are they Cretaceous or Tertiary", by Dr. B. Sahni in your journal.[1] I would have written before had I seen this valuable contribution earlier, but I have only recently returned from leave.

The occurrence of plant remains and a lacustrine fauna has long been known by the fossils found in the inter-trappean beds of the Deccan trap lavas of Nagpur and Chhindwara, which are considered as among the lowest flows of the volcanic series. There is thus no question that Dr. Sahni's remarks apply to the believed basal beds of the Deccan Traps.

The official opinion in regard to the Deccan Volcanic series is that three main sub-divisions have been recognised, which, arranged in order of their outpouring, may be placed in the stratigraphical succession as follows:

III. Upper Traps of Bombay and Western India;
II. Middle Traps of Malwa and Central India; and
I. Lower Traps of Nagpur and Central Provinces.

This arrangement is based on general conclusions and not on continuous geological mapping from say Nagpur to Bombay, where the geologist could walk on these basaltic lavas all the way. Consequently, these problems of the age of an entire volcanic series cannot be settled by the evidence of the fossils of an assumed horizon.

The strata immediately below the Deccan traps in the Nerbada valley and Central India are the Bagh Beds, which are unquestionably regarded as of middle to upper Cretaceous age. The Bagh Beds, a marine series, have been considered as the equivalent of the fresh-water infra-trappeans of the Central Provinces known as the Lametas. These rocks have not been clearly traced from one to the other by actual mapping.[2]

The age of the Lametas is thus in dispute,[3] but in this connection the infra-trappean beds (Lametas) of the Rajahmundry area, about Dudkur and Pangadi, are of considerable interest.[4] These beds are regarded as an estuarine deposit, the fauna of which is curiously Tertiary in assemblage, and considered somewhat younger (newer) than the Bagh Beds but still of Cretaceous age.

These infra-trappeans of the Godavari near Rajahmundry are of course related to the Deccan traps of that region. In these lavas, near Kateru, there are inter-trappean fossiliferous beds with a fresh- to brackish-water fauna, which appears to have no Tertiary affinities, and has relationships with the Upper Cretaceous rocks of South India. So far as I know this paradoxical evidence has not been re-examined by a competent palæontologist.

From the fact that palm fossil wood occurs in the inter-trappeans north of the Nerbada among the so-called Malwa Traps of Saugor[5] it is evident that the broad sub-divisions of the Deccan Trap series recognised above must be regarded as simply tentative. And I would say that the official opinion that the Deccan Trap series is entirely of Cretaceous age is largely out of date and not the view of those officers who are most familiar with these lavas, but a revised official opinion cannot be published without sufficient evidence.

It will be remembered that no less an authority than Dr. W. T. Blanford, after a personal investigation wrote[6] as follows, *in italics*:—

> "....that the lowest traps appear to differ less in age from the middle cretaceous beds of Bagh than the highest traps do from the lower eocene formations of Surat."

[1] *Curr. Sci.*, 1934, **3**, 134-136.

[2] *Mem. Geol. Surv. India*, 1860, **2**, 196.

[3] *Ibid.*, 1926, **51**, 102-103.

[4] *Man. Geology of India*, Part 1, 1879, 317.

[5] H. H. Spry, *Journ. As. Soc. Bengal*, 1833, **2**, 639; and W. T. Nicolls, *Journ. Bom. As. Soc.*, 1857, **5**, 614.

[6] *Mem. Geol. Surv. India*, 1867, **6**, 159.

and that Dr. T. Oldham[7] thought that the evidence then available did not support that generalisation, and favoured an Eocene age.

Dr. Sahni has drawn attention to these points, and I do not but accept Dr. Sahni's identifications and conclusions regarding the specimens and inter-trappean beds with which he has specifically dealt, but it must not be assumed that the whole question of the *age* of the Deccan Trap series is now settled because the evidence from Chhindwara points to a Tertiary age.

Dr. W. T. Blanford possessed an uncanny judgment and unrivalled knowledge of the Indian fossiliferous formations as a whole, in addition to a personal study of the Deccan Traps of Western India. His conclusions point to the volcanic period as possibly straddling the close of the Cretaceous and the beginning of the Tertiary era. This, I think, is the opinion of those of my colleagues with whom at odd times I have discussed this problem.

Mr. R. D. Oldham's cautious remarks in the 2nd edition of the Manual[8] indicate Dr. Blanford's respect, and all subsequent work on the stratigraphy of the Indian formations has shown the accuracy of Dr. Blanford's work and judgment. We would not alter any of his opinions now unless it was proved necessary by the evidence of exhaustive field work. He did not say that the Deccan Trap series as a whole were of Cretaceous age, nor do the traps of the Bagh area necessarily involve those of Nagpur. Dr. Blanford may have believed that the Nagpur traps came between the Bagh beds and the traps above the Bagh infra-trappeans of the Nerbada valley, but this is not definitely stated, and the evidence of the inter-trappeans of Kateru may have been used.

To give some idea of the nature of the problem involved I would like to say that I have traced the Deccan Trap lavas (and dykes and sills) across the head-waters of the Son River, from Amarkantak and South Rewa into Korea and Sirguja and on, to the Ranchi and Palamau districts. From Netarhat in the last-named area one may practically overlook the coalfield of Karanpura in the Damodar valley. This can be definitely done so from the most easterly of the laterite capped plateau of the Ranchi district north of Lohardaga.

In the Karanpura coalfield there are dolerite dykes the material of which is petrologically identical with the dolerite sills and dykes of the Deccan Trap in Rewa and Sirguja. The distance from the Karanpura coal-field to the most easterly Deccan Trap outlier, at Netarhat, is *under* 50 miles, while it is more than three times this distance to the nearest occurrence of undoubted Rajmahal trap which is established as of Jurassic age. It is *more* than 50 miles from the Rajmahal traps to the Giridih coalfield where dolerite dykes identical with those in the Karanpura and intervening—Jharia and Raniganj—coalfields occur. Because of proximity the dolerite dykes in the Giridih field were regarded as of Jurassic age, and this geological age was also given to the dykes in the Raniganj and Jharia fields. Had the earliest work been done from the west it is certain that a Deccan trap age would have been offered for all these intrusions in the coalfields. The dykes in the Karanpura field are exactly the same, even to the association of peridotites, as those in the Jharia and Raniganj and Giridih coalfields. The petrological similarity of the Deccan and Rajmahal traps has long been known.

Again it had been early suggested that the so-called Sylhet trap of Assam, which is definitely not only pre-Eocene but overlaid by fossiliferous Upper Cretaceous strata might be the equivalent of the Rajmahal trap. I had thought[9] from specimens in our collection, that the Sylhet trap was different, petrologically, from the Rajmahal trap. However, during the last three years I have personally examined the Sylhet trap in the Khasi and Garo Hills and found these rocks, chiefly dolerite dykes, to be indistinguishable from the dykes in the Damodar Valley coalfields both in hand specimens and under the microscope. Here then is a pretty problem regarding the relationship of the Jurassic Rajmahal traps to the most easterly Deccan traps in Bihar.

I doubt if any of my colleagues who are fully acquainted with the subject of the Deccan traps hold the view that our official publications, quoted by Dr. Sahni, give, *i.e.*, that these volcanic eruptions were entirely confined to the Upper Cretaceous. The opinion is still that of Dr. Blanford in broad outline—that these Deccan lavas were poured out in the epoch which covers the close of

[7] *Rec. Geol. Surv. India*, 1871, **4**, 77.

[8] *Geology of India*, 1893, 282-83.

[9] *Mem. Geol. Surv. India*, 1930, **56**, 114.

the Mesozoic and the early beginnings of the Cainozoic eras. To me the nature of the eruptions has always appeared complex but I have felt that in a general way the earliest outburst of activity was in north-eastern India, and that, broadly speaking, the successive series of eruptions occurred in newer areas each further west than the previous until the volcanic period finally died out in north-western India.[10]

I am glad of the opportunity Dr. Sahni has given me to express the opinions I have as they represent the views of those of my colleagues with whom I have been able to discuss his paper. He knows me well enough to understand that I appreciate the importance of his palæo-botanical work and that I do not feel qualified to discuss the value of his determinations of plant fossils as absolute indicators of a geological horizon. Although I worked in the Chhindwara district for many years I did not include Mohgaon Kalan (22° 1′: 79° 2′), 18 miles east of Chhindwara and 4 miles south-east of Jhilmili railway station, in my mapping, but it is clearly in a trap area among the lower flows of the Chhindwara district. The question now arises whether these are really among the lowest lavas of the Deccan Trap series.

In conclusion I would like to say that not until we come to the Bagh beds of the Nerbada have any signs of marine conditions been discovered for the Cretaceous Sea, while the Nummulitics of Surat show the presence of the sea in Eocene times. It follows simply from this that an estuary opening westwards probably did exist during those geological epochs, but it is difficult to believe in the persistence of this estuary in the intervening period (epoch) as it was almost certainly filled up by the Deccan trap lavas. These, accepted as of sub-ærial origin, are known to be at least 2,000 feet thick in Kathiawar. We are convinced that the break-up of the Gondwana continent, by a great series of subsidences of the land westward under the waters of the Arabian Sea, did not become fully effective, so far as the west coast of India is concerned, until after the close of the Deccan volcanic eruptions. The main features of the present configuration of the west coast of India appear not to have become fully established until the late Eocene period, although faulting continued long afterwards in Miocene times and later. I have drawn a series of maps showing the distribution of land and sea at various periods in the Mesozoic and Cainozoic eras, which will shortly be published in my memoir on "The Tertiary Coalfields of India" (now in preparation).

CYRIL S. FOX.

Geological Survey of India,
27, Chowringhee, Calcutta,
February 7, 1935.

[10] *Rec. Geol. Surv. India*, 1925, **58**, 90.

I AM thankful for an opportunity of reading Dr. Fox's valued comments on my note suggesting a Tertiary age for the Deccan Traps.

It is satisfactory to learn that the official view as expressed in the Geological Survey's publications is not shared by those of Dr. Fox's colleagues who are most familiar with these lavas. Assuming, as Dr. Fox agrees, that the flows of Nagpur-Chhindwara are the oldest in the series, the palæobotanical evidence from that area distinctly supports the view that the date of the earliest eruptions was later than the Uppermost Cretaceous. In this connection, the evidence from Mohgaon Kalan and Sausar Tahsil alone is of considerable significance, because the *Nipadites* came from the former locality of which the flora is dominated by palms, while the *Azolla* abounds in the cherts of the Sausar region. Without further evidence, it would be difficult to say how much younger the Bombay Traps are than those of the Central Provinces and of Malwa and Central India. The mere fact of the occurrence of fossil palm wood in the inter-trappeans of Saugor (Central India) can be of no help to us here. The indications are that the whole period represented by the traps from Nagpur as far as the west coast was comprised within the lower Tertiary and probably within the Eocene. But I must not trespass upon ground which is not familiar to me: I am not aware of any palæobotanical facts in support of this view.

However, the main point is that if the testimony of the plant-remains is to be relied upon we must agree that the Tertiary era had already dawned when the first lavas of the Deccan were poured out. We shall no doubt soon be in a position to check this conclusion independently because precise methods are now available for calculating

the geological ages of igneous rocks from the evidence of their radioactive minerals.

B. SAHNI.

Department of Botany,
University of Lucknow,
February 15, 1935.

A Note on the Origin of the Kaldurga Conglomerates, Mysore.

IT is well known that the question of the probable mode of origin of the Kaldurga (13° 39′ : 75° 54′) conglomerates has had an interesting history. Till the year 1908 these and other similar conglomerates elsewhere in Mysore were described as sedimentary. Later, Dr. W. F. Smeeth examined the Mallappanhalli and Aimangala conglomerates of the Chitaldrug Schist belt during the field season 1909-1910, and pointed out certain evidences in favour of their being considered as autoclastic in character and *not* of the nature of true sedimentary conglomerates. This idea was soon extended to all the other conglomerates of Mysore; every one of these was shown to fit in with the "autoclastic" theory and the original suggestion of these being true sedimentary conglomerates came to be completely abandoned.

In the course of a recent examination of these conglomeratic rocks near Kaldurga—the classical area where the autoclastic nature of the conglomerates was considered to have been definitely established by Mr. P. Sampat Iyengar—I have made two observations which I consider interesting and important.

(1) The conglomerate is often crowded with a large number of pebbles of a varied character. For instance, I collected a specimen from the south of Kaldurga, about 6″ × 9″ in size, containing more than twenty-five pebbles composed of such widely different rock types as gneiss, granite, quartzites (two types), vesicular spilite and altered dolerite. From other specimens in the locality, I obtained pebbles of banded quartzite, limestone, vein quartz, etc. Several of the rock masses from which these pebbles must have been derived are now far away from the area where these specimens are found. The most interesting pebble seen in one of the exposures of this conglomerate, is of the "Galipuje felsite"; this pebble must obviously have been derived from the *in situ* occurrence of this rock near Galipuje, about sixteen miles away from the spot where the pebble was noticed in the conglomerate.

(2) In another part of the conglomerates, near Aladhalli (about four miles south of Kaldurga), I find the conglomerate showing a striking gritty character; and what is more interesting, some of these grits show a distinct graded bedding. The rock here has layers about a foot in thickness, one overlying the other. Each layer starts with a more or less coarse pebbly character and gradually becomes finer and finer, till the next layer again starts abruptly with coarse pebbles, grading on into fine. (*Vide* Fig. 1.)

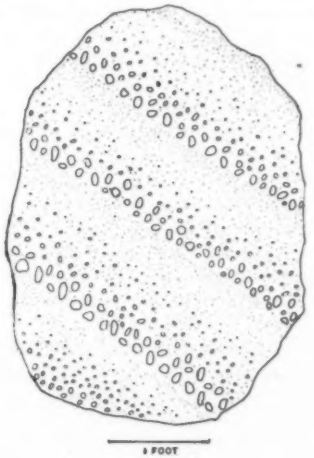


Fig. 1.

Boulder of conglomerate showing graded bedding.

It is difficult to understand how these two facts of observation could be reasonably explained on the basis of the "autoclastic" theory. On the other hand, they appear to me to be distinctly suggestive of an original sedimentary character for these conglomerates. A more detailed investigation of these rocks is under progress and when this is complete, it may be possible to show that the conglomerates dealt with here are really of sedimentary origin though it is true that subsequent crushing and shearing have tended to obscure their original nature.

CHARLES S. PICHAMUTHU.

Department of Geology,
University of Mysore,
February 12, 1935.

A Microchemical Test for Protein Grains in Plant Cells.

By R. H. Dastur and U. K. Kanitkar,
Botany Department, Royal Institute of Science, Bombay.

PROTEINS and their products of decomposition yield a variety of colour reactions each characteristic of a particular group of nucleus. These reactions are not directly applicable for their detection when they occur with other interfering substances as they do in plant cells. The cells of leaves, in particular, offer exceptional difficulties, on account of the presence of the green chlorophyll.

We have developed in our laboratories a convenient and reliable michrochemical method which has been found useful in the study of the synthesis of proteins in the leaves of *Abutilon asiaticum* G.Don., and those of *Ricinus communis* L., under exposure to artificial light.

Folin and Wu's[1] β-naphthoquinone-sulphonic acid colour reaction found applicable for the detection of amino acids in blood was extended to plant cells. Sections of tissue under examination are first treated with alkaline β-naphthoquinone (2 c.c. of 0·5 per cent. aqueous solution of the sodium salt of β-naphthoquinone-sulphonic acid + 1 c.c. of 1 per cent. sodium carbonate and 4 drops of 1 per cent. phenolphthalein) for 30 hrs., then transferred to a mixture of acetic acid (50 per cent.) and sodium acetate (5 per cent.), washed for half minute, treated with a 4 per cent. solution of sodium thiosulphate for 5 minutes, washed, dehydrated and finally mounted in glycerine. On examination under the microscope, the presence of amino acids in the leaf, petioles, cotyledons and hypocotyledonous regions of the seedlings and radicles of the beans and gram is revealed. The method, however, suffers from the disadvantage that it is not specific to proteins, since their degradation products also respond to the test.

A reagent obtained by dissolving 0·2 gm. of orthoquinone in 20 c.c. of 95 per cent. ethyl alcohol and mixed with 1 c.c. of 1 per cent. sodium carbonate solution has proved satisfactory as a specific reagent for proteins. Preliminary trials with rice and wheat grains definitely indicate that while the starch and other non-proteinous matter are not stained, the protein grains in the aleurone layer take up a deep colour. It should be mentioned however that the reagent stains the protoplasm but the protein grains are more deeply stained and are therefore distinguishable from the surrounding protoplasm.

In the case of leaves, the interfering chlorophyll is first removed by treatment with hot boiling 20 per cent. alcohol for 15–30 mins. The leaf is then kept in the orthoquinone reagent for 2 days and after washing with alcohol sections are cut, mounted and examined under the microscope. The deeply stained protein grains are easily distinguishable. This procedure has proved invaluable in the study of the size and number of protein grains in cells.

[1] *J. Biol. Chem.*, 1922, **51**, 377.

The Public Health of India.

THE Report of the Public Health Commissioner for 1931 which has now become public is a valuable document dealing with Vital Statistics, Antimalarial and Anti-tuberculosis campaigns, Leprosy surveys, etc., and several other topics of public health interest. The infantile death rate was high—more than double that in Germany, England & Wales and South Africa. Tuberculosis was on the increase and the anti-tuberculosis campaign had not proceeded very far. The Leprosy Survey clearly indicated that the disease was much more prevalent than was formerly supposed.

Major-General J. D. Graham, Public Health Commissioner, recommends the formation of a Ministry of Health, an organisation which shall be competent to frame and conduct a Public Health Policy for the country as a whole.

Fertile Pedicelled Spikelets in Sorghum.

By G. N. Rangaswami Ayyangar, B.A., I.A.S.,
Millets Specialist, Agricultural Research Institute,
and
V. Panduranga Rao, M.A.,
Assistant, Millets Breeding Station, Coimbatore.

SORGHUM grains develop in sessile hermaphrodite flowers. The sessile flowers have normally attached to them at least one pedicelled flower. These pedicelled flowers have the usual floral envelopes or occasionally, vestiges thereof. They are not usually obtrusive; however, in a few varieties they are prominent and give the ear-head a prickly look. They serve as a padding between the sessile flowers. Sometimes there are two pedicelled flowers one on each side of the sessile. In stray cases sessiles without pedicelled flowers attached to them occur. Sessiles with three pedicelled spikelets are a rarity. Almost all pedicelled spikelets are barren. In the terminal spikelets, where these are in pairs, odd flowers bear anthers. Long,[1] after an extensive examination of the spikelets of *Andropogon halipensis* and *Andropogon Sorghum*, var. *sudanensis*, comes to the conclusion that the aborted pistil of the pedicelled flower suggests that it once had a perfect flower.

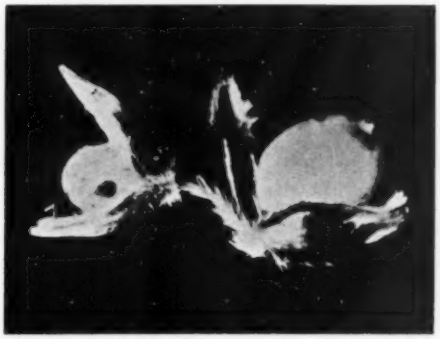
An intense botanical examination of the varieties of sorghum at the Millets Breeding Station, Coimbatore, showed three varieties which had pedicelled flowers with seeds (Illustration): A.S. 3441 and M.S. 2687 (from East Africa), and M.S. 1644 (from Bihar). In the two sorghums from Africa all the pedicelled spikelets had both anthers and ovaries at flowering time but not all ovaries developed grains. The analysis of a head in each showed as follows :—

	Total number of pedicelled spikelets with ovaries	Number of pedicelled spikelets with grains	Percentage of grain formation in pedicelled spikelets
A.S. 3441 ..	2,683	1,647	61
M.S. 2687 ..	4,274	945	22

In M.S. 1644, the Indian variety in which the manifestation of this fertility was very poor, 40 heads were analysed and the incidence of grain-bearing pedicelled spikelets was noted. Twenty-five heads showed under one per cent., ten heads two to three per cent. and five between four and eight per cent. of grain-bearing pedicelled spikelets. The rest of the pedicelled flowers were antheriferous.

The seeds from pedicelled spikelets were normal but smaller than those in the sessile spikelet. Weights of 200 grains showed them to be half the weight of grains from sessile flowers. This halving in size is in consonance with the disability of being pedicelled. Germination tests proved them to be as viable as normal grains.

The distribution of the hermaphrodite pedicelled spikelets in the successive whorls from bottom to top of the panicle was gone into and it showed that there was a progressive increase towards the top. In M.S. 2687 it rose from 5 to 21 per cent., in M.S. 1644 from 4 to 33 per cent. and in A.S. 3441,



Sessile spikelet with pedicelled grain-bearing spikelet attached. ×3.

the African variety which had the largest manifestation of pedicelled hermaphrodites, it was 53 to 85 per cent. In the terminal sessile spikelets, where the pedicelled flowers are mostly in twos, one or both developed seeds. It can be said that generally all the spikelets towards the periphery of the panicle produce grains. Those towards the centre of the ear-head fail to set seeds. Pedicelled

[1] *Bot. Gaz.*, 1930, **89**, 154.

flowers with ovaries only and no anthers were not met with.

The pedicelled flowers, when they are antheriferous, start opening at about the close of the main wave of the anthesis of sessile hermaphrodite flowers (G. N. Rangaswami Ayyangar and V. P. Rao, 1931).[2] The hermaphrodite pedicelled spikelets, however, flower *along with* the sessile flowers. The second wave of anthesis, usually met with in those sorghums which have antheriferous pedicelled spikelets, is absent in the case of panicles in which both sessile and pedicelled spikelets are hermaphrodite.

In all the three cases reported above, it is noticeable that this phenomenon of hermaphrodite pedicelled spikelets occurred in varieties in which the size of grain in the normal sessile hermaphrodite is distinctly smaller than the average grain in Grain Sorghums. It has been noted that in pedicelled spikelets the grains were about half the size of those in the sessile ones. This smallness in small grained ear-heads gives the panicle in which this phenomenon is recorded, a minuteness of grain disposition, not usual in this Great Millet.

The occurrence of grains in pedicelled spikelets opens up the possibility of breeding an all-fertile ear-head in spite of the basic drag of the sterility of pedicelled flowers which characterises the Andropogons. The smallness of grain is a disability to be faced. A big grain is a desideratum in a Grain Sorghum. Crosses designed to explore the possibilities of this combination are in progress.

Above all the concurrent flowering of the hermaphrodites whether pedicelled or sessile, without falling back as a second wave as in the case of pedicelled antheriferous spikelets, leads to the possible relationship of factors responsible for the opening of flowers and the part that a full sexual complement plays in that process.

Abnormal Fruits—Viviparous Germination in *Coccinia indica* W & A. (Family *Cucurbitaceæ*).

By M. Ghouseuddin and M. Sayeeduddin,
Osmania University, Hyderabad, Deccan.

THE object of this note is to record a rather advanced stage of what is called viviparous germination in *Coccinia indica*. One of the authors, M. Ghouseuddin, collected a few fruits from a plant growing near the tank in the Public Garden, Hyderabad. They show viviparous germination in a very advanced stage in that a tendril and a leaf have found their way out of the fruits (Fig. 1).

Viviparous germination has been recorded in the family *Cucurbitaceæ*, *viz.*, in melon in a considerable detail by Sir Thiselton-dyer. But in the specimens he has described the seedlings were still within the fruit and could not penetrate the fleshy and solid pericarp to find their way out. Only in one instance did he find a tap-root actually penetrating the solid parenchyma of the pericarp. The cotyledons were green but the chlorophyll came out in alcohol very readily, and did not impart good enough colouration to the alcohol.

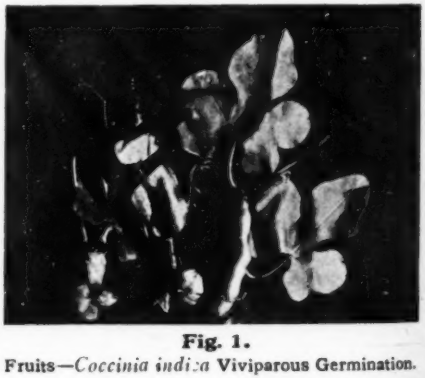


Fig. 1.
Fruits—*Coccinia indica* Viviparous Germination.

Viviparous germination has long been known in Mangroves (*Rhizophoraceæ*), and it often occurs in *Citrus* fruits, *Carica Papaya*, *Dipterocarpus retusus* (*Dipterocarpaceæ*), *Bertholletia excelsa* (*Lecithydaceæ*), etc. But as far as we are aware, cases have not been recorded in which the seedlings were so well developed as in this case; the shoot comes

[2] *Ind. J. Agri. Sci.*, 1931, **1**, 445.

out of the fruit, the latter being still on the parent plant.

Coccinia indica is a member of the family *Cucurbitaceæ* and it is not surprising at all to find viviparous germination of seeds in it, but what is most striking is that the shoot has managed to pierce through the fruit while the latter being still on the parent plant. The fruits are quite intact and there is not the slightest sign of any disintegration.

Referring to the mode of germination in *Cucurbitaceæ*, we find that the cotyledons come above ground as the first leaves of the plant. In our case it seems that one of the two cotyledons is transformed into a leaf and the other into a tendril. As the tendrils in the *Cucurbitaceæ* have always been a subject of great controversy the present finding of ours might serve as a further proof in favour of one of the theories advanced regarding the nature of the tendrils in this family.

The theories in brief are the following :—

(1) A tendril in the family *Cucurbitaceæ* is one of the bracteoles of a flower which is an axillary shoot of a foliage-leaf. The tendril (bracteole) has been pushed of its original position on the primary shoot (or flower) to its present position by the side of the foliage-leaf (Braun's suggestion which has been adopted by Eichler and others).

(2) Twining part of a tendril is a leaf-structure; lower stiff portion is a stem-structure (Muller).

(3) Modified stipules, *viz.*, in *Kedrostis spinosa* (Engler).

(4) "The developmental history of the individual tendril shows in many cases clearly the direct transformation of the primordium of the foliage leaf into a tendril, the leaf-lamina being rudimentary (Goebel).

Anatomical studies are in progress, and the final conclusion as to the nature of the tendrils in this particular case must be reserved till their completion.

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Cause of Formation of a Heterocœlous Vertebra in Bird.

By Himadri Kumar Mookerjee,

Zoology Department, Calcutta University.

IN a recent communication in *Nature*[1] I have shown how procœlous, ophisthocœlous and amphicœlous vertebræ are formed. In each of these forms of vertebra the formation of the notochord is the starting point. Soon after the formation of the notochord and its peripheral sheaths the skeletogenous cells aggregate round them forming an outermost jacket as perichordal tube. The vertebral portions of the perichordal tube soon become cartilaginous while the intervertebral portions of it remain membraneous or procartilaginous for a considerable time. I have shown for the first time that through these intervertebral zones of perichordal tube, the migratory connective tissue cells enter.[2,3]

A strand of migratory connective tissue cells normally enters through the intervertebral zones of the perichordal tube, keeping its direction at right angles to the notochord. It has already been pointed out that procœlous, ophisthocœlous and amphicœlous forms are produced by various types of movement of the embryos at the time when the migratory connective tissue cells are actively entering the intervertebral zones of the perichordal tube.

In a heterocœlous form, such as in most birds, the formation of the vertebra is a modification of the procœlous type. Like the tadpole, the embryo of bird oscillates its body in clockwise and anti-clockwise directions, while its head is kept in a so-called stationary condition. For the mode of movement of the embryo we will have to infer it from the direction of the line of curvature formed by the migratory connective tissue cells. An analogy may be

[1] Mookerjee, H. K., *Nature*, 1934, **134**, 182.

[2] Mookerjee, H. K., *Phil. Trans. Roy. Soc.*, 1930, **218 B**, 415.

[3] *Ibid.*, 1931, **219 B**, 165.

drawn from that of the tadpole, where we can actually see that during its embryonic stage the forward movement is effected by the oscillation of the tail while its head remains stationary (Fig. 1). This leads to a change in the direction of the migratory

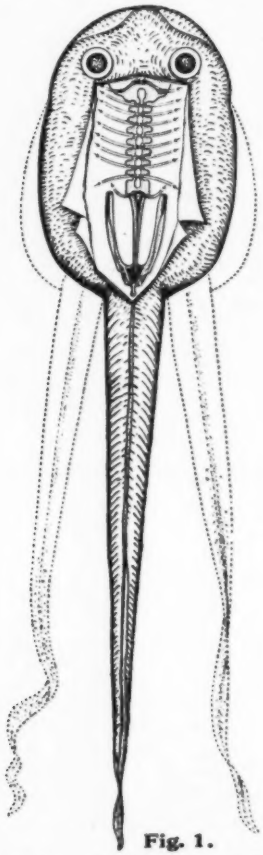


Fig. 1.

Diagrammatic figure of the tadpole of *Rana temporaria* on which frontal section passing through the centra of the vertebral column is superimposed. Oscillation of the embryo is shown by dotted lines. The path of migratory connective tissue cells has been shown by two consecutive lines through the intervertebral zones of the perichordal tube indicated by arrows on both sides. (After Mookerjee).

connective tissue cells from perpendicular to the notochord, to a curve, the concavity of which is directed towards the cephalic end. The actual so-called procœlous vertebræ are formed when a split appears within the zone of curvature formed by the migratory connective tissue cells. A synovial cavity appears within the split. One point that should be noted here with regard to the formation of the heterocœlous vertebra, is that the migratory connective tissue cells

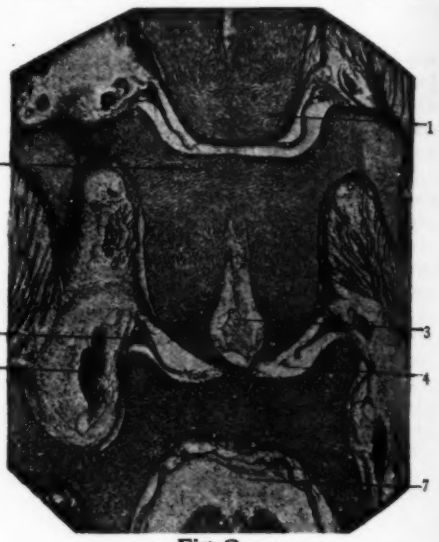


Fig. 2.

A Photomicrograph of the frontal section passing through the centra of three consecutive cervical vertebræ of chick embryo at 16 days incubation. ×40.

1. *vertebral condyle*; 2. *vertebral socket*; 3. *notochord*; 4. *synovial cavity*; 5. *intervertebral ligament*; 6. *spinal nerve ganglion*; 7. *spinal cord*.

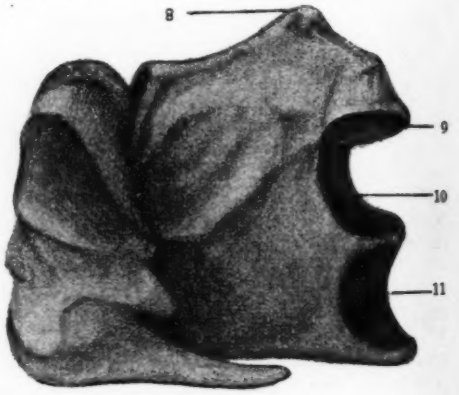


Fig. 3.

A side view of an adult cervical vertebra of common fowl. ×8·5.

8. *neural spine*; 9. *postzygapophysis*; 10. *neural canal*; 11. *heterocoelous vertebral condyle*.

instead of entering the intervertebral region in one band like that of a tadpole, enter the intervertebral region as three consecutive

bands as in the fry of fish.[4] The middle band quickly becomes a ligament, whereas the two lateral bands eventually become procartilaginous (Fig. 2). As in the tadpole we get here a condyle and a socket formed from the two lateral bands, and in between the two there forms a synovial cavity in which lies the intervertebral ligament. In order to accommodate this intervertebral ligament the condyle has a depression on the top (Fig. 3). The depression is also present in the socket, but would not be so prominent as on the condyle for the simple reason that the socket itself is a depression or cavity. Thus we get a heterocœlous or saddle-shaped vertebra

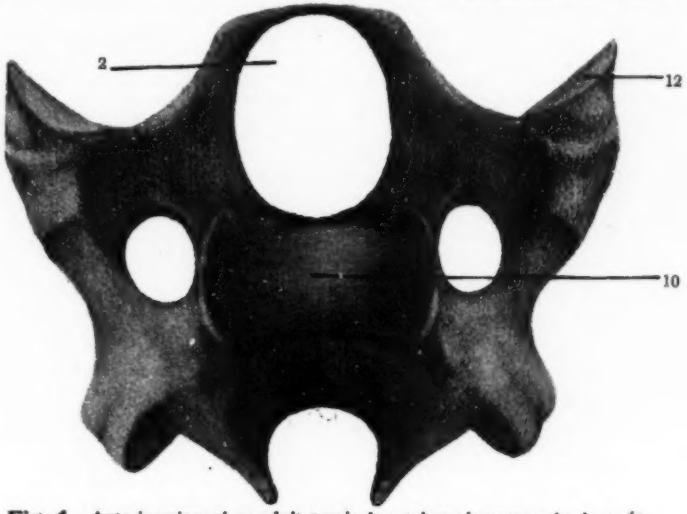


Fig. 4. Anterior view of an adult cervical vertebra of common fowl. × 16. 12. *Prezygapophysis.* (*Others as in* Figs. 2 & 3.)

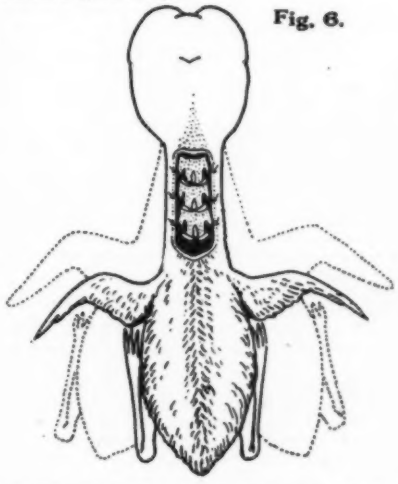
with socket in front (Fig. 4) and a condyle at the posterior end (Fig. 5), of a vertebral centrum with a depression on the top of it, as a modified form of procœlous type (Fig. 2). Fig. 6 shows the diagrammatic

Fig. 5. ×10.

Posterior view of an adult cervical vertebra of common fowl. ×7·5. (*Lettering as in* Fig. 3.)

[4] Mookerjee, H. K., *Curr. Sci.*, 1934, **2**, 342.

Fig. 6.



Diagrammatic figure of the embryo of chicken on which frontal section passing through the centra of the vertebral column is superimposed. Oscillation of the embryo is shown by dotted lines. The path of migratory connective tissue cells has been shown by two consecutive lines through the inter-vertebral zones of the perichordal tube indicated by arrows on both sides.

view of the path of oscillation of the vertebral column of bird.

Thus we may say that those animals that oscillate their cephalic end during the embryonic stage when the migratory connective tissue cells are entering through the intervertebral zones of the perichordal tube have ophisthocœlous, and those that move their posterior portion of their body, keeping the anterior end in a so-called stationary condition generally have procœlous and when there is an intervertebral ligament intervening between the ball and socket of a procœlous vertebra we get a depression on the top of the ball of the centrum in order to accommodate the intervertebral ligament forming a heterocœlous vertebra, while those that do not oscillate their body and keep them in a so-called stationary condition generally have amphicœlous vertebra.

So we may conclude in the words of Prof. MacBride, "Habit changes first and structure a long time afterwards. Habit is the real driving force in evolution."

Irrigation Research in the Bombay Presidency.

1. THE Special Irrigation Division was opened in June 1916 and in 1927 the Irrigation Development and Research Circle was created to apply the results of research on a large scale.

In 1930 the Development and Research Division was opened in Sind. Owing to shortage of funds the Irrigation Development and Research Circle was abolished in 1933 on the recommendations of the Reorganisation Committee. Land drainage—which amounts to application of research—has been handed over to the local engineers, and research work to a new Irrigation Research Division. Continuity has been maintained due to the application of research being controlled by the same officer who previously directed research.

2. When waterlogging and salt efflorescence investigations were started in 1916, soil physics was found to be an exceedingly important factor. A staff of agricultural graduates was gradually built up under whom sub-soil classification from surface indications was worked out. This was a long and many-sided investigation of great interest—covering geology, soil physics, ecology, and the flow of sub-soil water. These investigations led to an entirely successful theory regarding drainage requirements being evolved. Since then several drainage schemes have been constructed by the Special Irrigation Division, with highly satisfactory results.

3. Simultaneously the disposal of the sewage effluent from Poona was undertaken—using it to irrigate a large cane area to the east of Poona. To investigate this question 60 acres of land were acquired near Hadapsar.

4. The corollary to the solution of the drainage problem was that of reclaiming damaged land. In many parts of the Canal tracts reduction of waterlogging combined with good cultivation was sufficient to restore the condition of the soil, but research had to be done in connection with soils, which had been damaged by salt efflorescence as a result of which they had become sodiumised.

5. The first drainage and reclamation works were carried out at the Baramati Experimental Salt Area (on the Nira Left Bank Canal) where some 160 acres of the worst land in any of the Canal tracts were acquired and drained. Of the 134 acres of land in the Baramati Experimental Salt Area, 100 acres are now suitable for growing good crops of sugarcane.

6. Drainage and reclamation methods soon gave promising results; so problems in connection with irrigation—by which is meant "increasing the fertility in soils by an artificial supply of water"—were then investigated. The policy regarding irrigation was *to modify agricultural methods to fit irrigation limitations, and to mould irrigation practice to meet agricultural requirements.*

7. This necessitated improved control of water by measuring and regulating devices, which led to the introduction of Standing Wave Flumes and Gibb modules. To perfect the design of these and other measuring devices, model experiments were started. These proved highly successful, and the work done at the Hydrodynamical Research Station soon became widely known, so that requests to test designs by models were frequent. This work became so important—largely because of the remarkable facilities at Poona—that many problems concerning Sind irrigation—especially in connection with Sukkur Barrage and Canal designs—were dealt with. These included :—

*(1) Modification of design of Barrage floor to keep the standing wave close to the Barrage under all conditions of flow,
*(2) Best design for Barrage piers,
†(3) Best design of divide walls.
‡(4) Silt exclusion from Barrage Canals,
§(5) Dissipating energy below falls,
(6) Silt exclusion from Mithrao Canal,
(7) Coefficients of discharge of Barrage Gates on running and falling gauges,
(8) Relative merits of various types of falls for dissipating energy.

Hydrodynamical research work is steadily widening in extent and importance—largely due to the new Research Station at Khadakvasla near Lake Fife (11 miles from Poona) where very exceptional facilities for discharges of clear water up to 500 cusecs under constant head are available.

8. One of the direct results of drainage research was the necessity for restricting sugarcane irrigation in the absence of drainage. The whole of

*(1) & (2) *Technical Paper* No. 29.
†(3) *Technical Paper* No. 52.
‡(4) *Technical Paper* Nos. 45 and 46.
§(5) *Technical Paper* No. 44.

the Deccan canal areas have therefore been surveyed as regards substrata and subsoil water levels and their connection with irrigation and percolation from channels.

Based on this, soils have been classified as regards permissible intensity of irrigation—with and without land drainage—and limits of cane irrigation have been fixed by catchments and sub-catchments.

Similarly fruit gardens have been restricted to areas where the most suitable soil-cum-drainage conditions will continue to prevail.

9. The block system, originated in 1906 by Sir M. Visvesvaraya, has been improved by unitisation and standardisation and is now enforced on all the Major Canals in the Deccan.

10. In Sind the Development and Research Division was opened in 1930. Under it complete subsoil surveys of the Lloyd Barrage areas have been made and maintained up to date; much work has been done on models of various masonry works, resulting in standardisation of design: investigations into flumes, falls and flow in channels are in hand, and an important silt survey of the Indus, the Nara and the Jamrao Canal is also being carried out.

11. The formation of a Central Committee of Research, subsidiary to the Central Board of Irrigation, which was formed a few years ago, was a step of immense importance to the future of all-India Irrigation Research.

12. 25 Bombay Public Works Department Technical Papers dealing with the researches carried out in the Deccan and 10 dealing with those in Sind have been published and are obtainable from the Superintendent, Government Printing and Stationery, Bombay; through the High Commissioner for India, India House, Aldwych, London, W. C. 2; or through any recognised Book-seller.

Research Notes.

On a Theorem of Milloux.

DINGHAS (*Math. Zeit.*, **39**, pp. 590–596) has succeeded in generalising a theorem due to Milloux about integral functions of infinite order, by means of which he proves some results about a class of integral functions of infinite order which are analogous to some theorems in the theory of integral functions of finite orders—*e.g.*, Phragmen-Lindlöf theorem and Denjoy-Ahlfors theorem—on the maximum number of asymptotic values of an integral function of finite order. The theorem that he proves (analogous to Phragmen-Lindlöf theorem) at the outset is that if an integral function $f(z)$ satisfies the conditions set forth below in the infinite strip defined by $z = x + iy$,

$$x \geqslant 0, \quad |y| \leqslant \frac{\pi}{2k},$$

$$\overline{\lim_{n\to\infty}}\; e^{-\rho x} \operatorname{Log} M_0(x) = 0, \qquad [\rho > 0, \text{ and finite}]$$

$$\overline{\lim_{n\to\infty}}\; e^{-\rho x} \operatorname{Log} M(x) = \sigma \neq 0$$

where $M_0(x) = \operatorname{Max} \left| f\left(t \pm \frac{\pi i}{2k}\right) \right|$ for $0 < t \leqslant x$,

and $M(x) = \operatorname{Max} |f(x+iy)|$ for $|y| \leqslant \frac{\pi}{2k}$,

then $k \leqslant \rho$.

The proof of this theorem depends on the following lemma. If $g(z)$ is an integral function, satisfying the conditions

$$\left| g\left(x \pm i\frac{\pi}{2k}\right) \right| \leqslant M_0. \quad |g(x+iy)| \leqslant M,$$

$$|g(iy)| \leqslant M_0 \quad \text{in } 0 \leqslant x \leqslant a, \quad |y| \leqslant \frac{\pi}{2k}$$

(It is supposed that $M_0 < M$)

then $\log |g(z)| \leqslant \log M_0 + \frac{4}{\pi} \log \frac{M}{M_0} e^{k(x-a)}$.

After the proof of this theorem he introduces the notions of order, type, etc., for a class of integral functions of infinite order. [The order ρ is defined as $\operatorname{Lim} \frac{\log \log M(x)}{x}$, where $M(x)$ is the maximum of $|f(z)|$ for $|y| \leqslant \frac{\pi}{2T}$. With these definitions he proves the following interesting result.—There does not exist any integral function of order ρ (in the new sense) in a strip of breadth less than $\frac{\pi}{\rho}$ and which is of minimal type if it is of the same order in any sub-region of the strip and which is of either the maximal or the normal type. After proving another lemma he deduces another interesting result in connection with this class of integral functions which is analogous to the Denjoy conjecture about the asymptotic values of an integral function of finite order which was proved by Ahlfors in 1930.

K. V. I.

On the Prime-Numbers of Some Arithmetical Progressions.

ERDOS (*Math. Zeit.*, **39**, pp. 473–491) develops a method for the proof of the

Bertrand-Postulate in the case of prime-numbers of an arithmetical progression $a+nd$ $[(a,d)=1]$. On account of the generalised prime-number theorem the Bertrand-Postulate (that there exists prime-numbers out of $a+nd$ between ξ and 2ξ) is true provided ξ is taken sufficiently large. [The limit depending on a & d.] Breusch had proved by considering the numerical positions of the first few zeros of the corresponding ζ-function that Bertrand's Postulate is true in the case of the progressions $3n \pm 1$, $4n \pm 1$, if $\xi > 10^6$, and by reference to a prime-number table he reduced the upper limit 10^6 to 7. The author's method is elementary and as such it is applicable in the case of only a few progressions. The method is analogous to the Tchebechef proof of the theorem that $\pi(n) = O\left(\frac{n}{\text{Log } n}\right)$. He introduces an integral expression

$$P_n(a,d) = \frac{\prod_{p|d} p^{\left[\frac{n}{p-1}\right]} \prod_{k=1}^{n} (a+kd)}{n!}$$

and proves some results in connection with its order and its structure (*viz.*, divisibility by primes, etc.). It is interesting to note that this method also enables him to give *elementary* proof of Dirichlet's theorem about the occurrence of an infinite number of prime-numbers in an arithmetical progression in the case of arithmetical progressions for which $\sigma(d) = \sum_{\substack{p \nmid d \\ p<d}} \frac{1}{p} < 1$. By means of a numerical table which he has constructed he deduces that in all cases where $d<29$ this method is applicable; but in the case of $d=7$, 11, 13, 25 and 27, $2d$ is to be taken as the difference and in the case of $d=17$, 19, 23, $6d$ is to be taken as the difference. He also proves that if $\sigma < \frac{d-2}{2(d-1)}$ then Bertrand's Postulate about the progression $a+nd$ is true if ξ is chosen sufficiently large. This applies to progressions of the form $6k\pm1$, $12k\pm1$, and $12k\pm5$. ($\therefore 4k\pm1$.) In the case of $d=6$, the sharper result that there exists a prime-number of the progression between ξ and $1{\cdot}5\ \xi$, is true if ξ is chosen large enough. He next sharpens this result to the case when $\sigma < \frac{1}{2} - \frac{d}{(d-1)(2d+1)}$. He also calculates the lower limits for ξ in the case of a few arithmetic progressions. The lower limits obtained are far smaller than those obtained from the functions-theory method.

K. V. I.

The Theory of Reduced Simple Continued Fractions (*Reduziert-Regebmässiges Ketten-Brüche.*)

ZURL (*Math. Ann.*, **110 B,** 5 Heft, pp. 679-717) has developed completely the properties of this type of continued fractions. Reduced simple continued fractions are continued fractions of the following form $b_0 - \frac{1}{|b_1} - \frac{1}{|b_2} - \frac{1}{|b_3} \cdots$ where b_v's are positive integers and $b_v \geqslant 2$ for $v \geqslant 1$. The paper is divided into three chapters. The first chapter deals with the introduction to the theory and concerns itself with the simple properties of convergents $\frac{A_v}{B_v}$, and the development of any number as a continued fraction of this type. Here are some of the interesting results (1) $\frac{A_v}{B_v}$ decreases monotonically,

(2) $\lim_{v\to\infty} [B_v - B_{v-1}] = \infty$,

(3) $\frac{B_{v+k-1} - B_{v+k-2}}{B_{v+k-2}} \geqslant \frac{1}{k}$.

The second chapter is devoted to the study of the way of approach of the convergents towards the number which is developed as a continued fraction of this type. Conditions for a fraction to be a convergent of a reduced simple continued fraction development of an irrational number are given which are analogous to the conditions in the case of the ordinary continued fraction development. We come across certain interesting results in the third chapter. Here we find a detailed and systematic study of periodic continued fractions of this type. Results some of whom are analogous to the classical theorems of Lagrange and Galois in conncetion with ordinary periodic simple continued fractions are enunciated and proved. The paper also contains a table which gives us the development of $\sqrt{D}$ [D = 2 to 99] as a continued fraction of this type. These developments possess one advantage over the ordinary continued fraction development; for, we can solve the diophantine equation $x^2 - Dy^2 = k$ by

means of the former for $|k| \leqslant 2\sqrt{D}$ and whereas by means of the latter we can solve the equation only for $k \leqslant \sqrt{D}$.

K. V. I.

"Bleeding of Cements."

ORDINARY Portland Cement when used for making concrete blocks, has a tendency to separate itself from the excess water used in the mixture, which has been termed "bleeding". Very often, this leads to disastrous results in dams and retaining walls on account of the voids created by the free water which is subsequently removed by evaporation or otherwise. It is usually found that cements of abnormally low surface area exhibit an excessive tendency to bleed. One of the ways of getting over the trouble has been in using Portland Cement ground to a fine state of division. The latest development in this field has been, in grinding standard cement clinker to a superior degree of fineness in presence of a small amount of organic dispersing agents which consist of polymers of condensed naphthalene sulphonic acids. An exhaustive study has been made by L. S. Brown (*Ind. Eng. Chem.*, 1935, **27**, 79) who has shown that the addition of such dispersing agents reduces the porosity of the gel; hence the loss of water and the formation of voids in the concrete is considerably diminished.

M. P. V.

The Vitreous State.

G. HÄGG (*J. Chem. Phys.*, 1935, **3**, 42) correlates the tendency for the formation of amorphous melts with the existence of atom groups kept together with strong attractive forces. A melt having such structures so large or irregular as to render the addition to a crystal lattice difficult shows a large tendency for supercooling and glass formation. Metals and simple compounds, which show little tendency to formation of such large or irregular groupings, do not form vitreous solids. On the other hand, a large class of substances such as the oxides of certain metalloids (such as Si, B, Ge) and the corresponding acids and salts show this quality in a large measure. This behaviour is attributed to the tendency on the part of metalloid atoms to co-ordinate oxygen in a definite way, which brings about the formation of complex structures which retard crystallisation. This hypothesis gives a rational interpretation of the diminished tendency to form glass-like melts in certain systems as the percentage of basic oxide is increased.

K. S. G. D.

Activation of Papain and Cathepsin.

RESULTS of a far-reaching character have been indicated by Purr (*Biochem. J.*, 1935, **29**, 13) in the course of his extensive investigation on the relation between intracellular enzymes and vitamins. It was known, for some time past, that sulphydryl compounds are specific activators for proteinases. In 1933, Purr discovered that vitamin C-Fe″ complex activated cathepsin and arginase and later Maschmann and Helmert (1934) showed that papain, a proteinase of vegetable origin, was activated by vitamin C in presence of bivalent iron salts, the vitamin C–Fe″ resembling in this respect HCN. The investigations reported in this paper show that the activation brought about by different agencies are all of a similar character.

Both vitamin C–Fe″ and pyruvic acid–Fe″ activate papain only indirectly, as they are unable to activate purified, reversibly inactivated papain (prepared according to the method of Purr [*Biochem. J.*, 1935, **29**, 5]. Unpurified commercial papain, on the other hand, is readily activated. From the observation on the effect of fixed SS-proteins on the activation phenomena of papain, it can be concluded that unpurified commercial papin contains fixed SS-forms of protein which the vitamin C–Fe″ complex in the presence of the papain complex converts into the SH-form. Neither the vitamin C–Fe″ nor the papain can bring about the reduction individually. Similarly when oxidised glutathione and vitamin C–Fe″ are added to inactive papain, the reduction of oxidised glutathione (or oxidised papain ?) is brought about. The activation of papain by vitamin C–Fe″ apparently depends on the presence of SS-groups either in the glutathione molecule or in the fixed SS-protein. The real activators of papain are the sulphydryl compounds and the observed activation by HCN, and by vitamin C, pyruvic acid and succinic acid in the presence of bivalent iron, is an indirect effect.

The activation phenomena of cathepsin are essentially similar to those of papain. The author concludes that papain and cathepsin in the active state are fixed

SH–proteins of definite constitution, while the reversible inactivation forms of these enzymes appear to be SS-forms.

B. N. S.

Occurrence and Distribution of Diatoms in the Punjab.

The Journal of the Asiatic Society of Bengal (1934, **29**, 307-309) contains "A Short Note on the Occurrence and Distribution of Diatoms in the Punjab" by M. Abdul Majeed. The author has pointed out that the bare wet garden lawns generally harbour a few species of *Navicula* and *Nitzschia*. The ponds, pools and tanks are the most productive places and the epiphytic Diatoms form an interesting part of the study of the algal-flora of the Punjab. Species of *Surirella* which are common in other districts have not been found in Lahore, whereas species of *Rhopalodia* and *Epithemia* seem to be restricted to Lahore and its outskirts. According to the author species of *Asterionella* and *Tabellaria* so prevalent in Europe seem to be absent in the Punjab.

Germ Layers of Certain Diprotodont Marsupials.

T. KERR has described some early blastocysts of certain Diprotodont Marsupials (*Quar. J. Micro. Sci.*, 1934, **77**, Pt. II, No. 306) and has studied the formation of the germ layers. An almost complete series of blastocysts from the unilaminar stage to that showing the appearance of the first rudiments of mesoderm has enabled the author to describe the origin of the endoderm and mesoderm. The former arises as a number of isolated mother cells which migrate inwards and forms a continuous layer, similar to that described by Hill in Dasyurus. Large included cells from which Hartmann derives the endoderm in Didelphys are rare and when they are present, show obvious traces of degeneration. The mesoderm arises as an active proliferation of cells of the ectoderm in the formative area. At first continuous with the ectoderm, this heap of cells later separates and forms a distinct layer.

The Zoological Relationship of the Conodonts.

FROM a long time there has been a keen controversy regarding the exact zoological affinity of the conodonts. The vertebrate palæontologists seldom claim them as remains of vertebrates, and the invertebrate palæontologists hesitate to classify them among the invertebrates. Thus there has been a tendency for each group of workers to force the ownership upon the other group. Indeed this group of animals seems to be mysterious since their remains have been classified in such diverse groups as Pisces, Annelids, Mollusca, Crustacea, etc. But for a long time, however, they have been regarded as the remains of a certain group of fishes. In a recent communication to the *Journal of Palæontology* (Vol. **8**, No. 4), H. W. Scott has made a detailed study of the conodonts from the shales of the Quadrant formation. From the characters he has deduced that the conodonts have a greater affinity to the group of Vermes rather than to fishes.

Sedimentation and Stratigraphy from Modern Points of View.

W. H. TWENHOFEL, the author of the well-known work *Treatise on Sedimentation*, has rendered a distinct service for geologists and sedimentary petrologists in particular, by reviewing the development of the study of sedimentation and stratigraphy from the earliest times, in his lecture before the Society of Economic Geologists and Mineralogists (*Journal of Pal.*, **8**, No. 4). The findings of most of the geologists like Wrener and Cuvier have been challenged since they were based on incomplete observations and in certain cases on lack of knowledge. Of late the detailed study of sediments especially by Barrell, Milner and Boswell has shown that sedimentation is a complex process and that all like sediments need not have the same history. The process itself depends upon a number of variable factors and the sediments should therefore be studied as products of environmental conditions. In the words of the author "the sediments are not dead substances, but fragments of ancient history of which the reading is destined to make necessary the rewriting of much geologic history and the redrawing of much ancient geography". The common tendency to make generalisations regarding the origin of similar sediments must be avoided. Each must be studied independently and therein lies the key to the palæogeographical conditions of the past.

The Skull of Holocephali.

OUR knowledge about the fish skull is far from being complete and recently a comprehensive account of the Teleostean skulls was published by William K. Gregory. The primitive groups like Holocephali have received very little attention and the paper by G. R. de Beer and J. A. Moy Thomas in the *Phil. Trans.*, 1935 B., **514,** is certainly welcome. The former author by a careful study of the available embryological material of Holocephali elucidates the real nature of the palatoquadrate attachment, the structure of the hyoid arch and the nature of the so-called ethmoidal canal. The pterygoquadrate is fused to the neuro cranium and an otic process is present. The skeleton of the hyoid arch is primitive and possesses pharyngohyal and epiphyal; it is non-suspensorial. The presence of the pharyngohyal points definitely to the conclusion that the ancestors were never amphistylic or hyostylic. The group Holocephali must have taken its origin from autodiastylic ancestor, from which also the selachian must have radiated. Thus the selachians are closely related to Holocephali. The third point which is stressed in the paper is about the ethmoidal canal; this canal is an extra-cranial space secondarily roofed over when the interorbital septum is formed.

Science Notes.

An Interesting Implement for Mud-fishing from Ullarbhag, Lower Bengal.—At a meeting of the Asiatic Society of Bengal held on 4th March, Dr. S. L. Hora gave an account of a device for securing *Jiol Machh* from marshy areas in Lower Bengal. "A circular basket of the usual material and make, about 9½ inches in diameter and 23 inches in total length, is used. One end of the basket is open and the mouth is strengthened by a circular band of broad bamboo-strips. At a distance of about 16 inches from the mouth, there is another band of bamboo-strips, after which the split-bamboo sticks are pulled together and secured by a loop of string. The loop is fastened to the nearest band. In this way, the other end of the basket is closed and made to serve as a handle for manipulating the basket.

"The split-bamboo sticks, which run lengthwise, are about half an inch apart so that when the open end is dragged through mud, it passed out through the wide spaces and only the fish are trapped inside the basket."

* * *

A Note on the Distribution of Gloriosa superba *Linn. (Vern:—Bechnag, Kulhari, Bisha, etc.) towards Vikarabad and its medicinal importance.*—Messrs. M. Sayeeduddin and M. Abdus Salam, write: "We pointed out in our previous communication to *Current Science*, Vol. II, No. 3, Sept. 1933, p. 83, that, while ascertaining the distribution of *Lantana camara* Linn. towards Vikarabad we met with at a spot about 24 miles from the Hyderabad city a striking association of Lantana, *Gymnosporia montana*, *Butea frondosa*, *Tectona grandis*, *Dodonæa viscosa* and *Gloriosa superba* of which the last named was found evidently for the first time in our excursions towards this side. There is no definite record of its having been found this side before. The only reliable information one can get of the Hyderabad vegetation is from two works namely *Forest Flora of Hyderabad, Deccan* by E. A. Partridge (Pub. 1911) and from *The Madras Journal*, Vol. XV (Pub. 1848) in which there are abstracts of botanical reports about Warangal and Dawlatabad districts. Partridge writes (p. 402) that "*Gloriosa superba* is very common everywhere, springing up after the rains in field-hedges and on the outskirts of forests." Later on he mentions "Common in hedges, chiefly on black cotton soil." The latter statement makes us believe that his observations were made chiefly towards the Marhatwari side where the soil is mostly black and very suitable for the growth of cotton. No mention is made about this plant in the *Madras Journal* either, in which besides others, many plants of medicinal importance have been recorded. *Gloriosa superba* too happens to possess a few valuable medicinal properties (*ref.* Kirtikar, *Ind. Med. Plts.*, and Watt, *Dict. Econ. Prod. I.*) and it is strange that this plant has escaped the notice and consideration of the author of the above botanical reports.

It was summer time when we last visited Vikarabad. But in order to make a preliminary survey of its vegetation during the rainy season we undertook an excursion recently in August 1934. What was most striking is the gradual spread of *Gloriosa superba* and its association with *Gymnosporia montana* (Family Celastraceæ) whose root-action is claimed by Mr. Abdur Rahman Khan (*ref. Osmania University Research Jour.*, 1934), to be one of those responsible for turning rocks into *morum*. In all the cases mentioned below *Gloriosa superba* was found chiefly on *Gymnosporia montana*, which seems to prefer rather dry situations and hard substratum. While *Gloriosa superba* does not seem to be restricted to any particular kind of soil, it seems to have its own associations.

The exact spots where this plant was found within a distance of about 52 miles from the Hyderabad city are the following:—

16 miles and 7 furlongs from the city—A single plant on *Gymnosporia montana*. Between 16 and 18 miles—At two spots again in the same association. Between 18 and 19 miles—At several places with *Gymnosporia*, profusely in flower. Between 20 and 21 miles—All cultivated land, in some places slightly hilly. No trace of *Gloriosa*. At 21 miles.—*Gloriosa superba* amongst dense vegetation consisting of *Gymnosporia*, *Dodonæa viscosa*, *Zizyphus* sp., and several herbs. Between 21 and 44 miles—No trace of *Gloriosa*. After this nearing Vikarabad it was noticed at one spot only. But it was to be found again in

the thick forest at "Anant Giri", a hill about 2 miles from the Vikarabad village.

It seems probable that *Gloriosa superba* has ultimately found its way towards Vikarabad from the Bombay side where it is met with in abundance. It seems to have followed the other course also from Bombay, that is *via* Aurangabad towards Hyderabad, and it was on this side, we believe, that Mr. Partridge made most of his observations as is evident from his statement that *Gloriosa superba* is found chiefly on black cotton soil. It is quite probable that *Gloriosa superba* has found its way recently towards Vikarabad. Further investigations are in progress.

* * *

Goat Breeding in Western India.—The Imperial Council of Agricultural Research has recently provided funds for a scheme of goat breeding to be conducted by the Government of Bombay.

There are two well-defined pure breeds of goat in Western India, (1) the Surti, a small cream-coloured, hornless animal, reared on stall feeding, and (2) the North Gujarat goat, largely reared on grazing and principally used for meat and hair production. The scheme is intended (*a*) to study the two breeds, the inheritance of their characters, their feeding and management contributing to high milk production, (*b*) to conduct feeding trials to ascertain the most suitable quantities and qualities of Indian foodstuffs and their most desirable combinations for high milk production and growth, and (*c*) to investigate the comparative hygienic and food value of goat milk for feeding children, patients and invalids.

The scheme will extend over a period of 10 years and the work will be carried out at 3 stations, Poona, Vadala and Ankaleswar. The Live-stock Expert to the Government of Bombay and the Nutrition Assistant with the co-operation of Mr. I. W. Moomaw and Rev. R. W. Fairbank will conduct the investigations.

* * *

Agricultural Research Institute, Delhi.—His Excellency the Viceroy performed the ceremony of laying the foundation stone of the Imperial Institute, at New Delhi on the 19th February. In the course of his speech His Excellency pointed out that the location of the Institute at Delhi which being more easily accessible will enable the staff to be in intimate touch with the Indian scientific workers, will remove the atmosphere of isolation, from which the Institute, situated as it was at Pusa, suffered so far.

Referring to the nature of research which the Central Institute will undertake, His Excellency said, "There are problems of fundamental research which it is not possible for each Province with the comparatively limited resources to undertake, nor is it advisable that in the investigation of such problems there should be duplication of effort, and therefore waste of energy and money.... It is my hope that the Institute will be regarded by the Provinces as an integral part of their agricultural organisation and that they would refer to it problems which are not of purely local interest or importance and which they consider suitable for investigation at the Central Place."

"A number of young men return every year from Europe and America after taking research degrees but many of them do not at once find the employment adopted to the full utilisation of their training. Any scheme which would make it possible for some of the best of them to devote their abilities to agricultural research would be of real benefit to India. This is a direction in which private philanthropy would largely help by endowing as in other progressive countries research fellowships tenable at the Central Institute."

* * *

Institute of Population Research in India.—The inaugural meeting of the Indian Population Conference will be held at Lucknow during the ensuing *Deivali* holidays under the auspices of the Institute of Population Research in India. The objects of this Institute which has recently been started are briefly to stimulate and organise population researches in different provinces of India, to co-ordinate such researches as are now being undertaken, to hold general and local conferences and to publish the results of researches and discussions at such conferences from time to time.

Population questions in India will play a great part in determining practical, economic, social and political programmes and it is the purpose of the Institute to collect statistics and data and systematise and co-ordinate scientific knowledge in respect of the various elements in the population problems of the country. Researches in the following special fields are now promoted under the Institute:—(1) Population, food supply and vital statistics: (2) Population, crops and agricultural practice: (3) Population and trend of population; (4) Indices of agricultural productivity and population trend in the U. P.; (5) Standards of living and cost of living indices; (6) Population, dietary and nutrition: (7) Anthropometric measurements of the inhabitants of U. P.; (8) Comparative study of the numerical variation of different castes and communities; (9) Economic and vital decline of the primitive people of India; and (10) Migration, rural, inter-provincial and overseas.

Further information regarding the Institute can be obtained from Prof. Radha Kamal Mukerjee, University of Lucknow.

* * *

Evaporation in India calculated from other Meteorological Factors, by P. K. Raman and V. Satakopan. (*Scientific Notes, India Meteorological Department*, Vol. VI, No. 61).—The paper contains a discussion of the mean monthly and annual evaporation at 80 stations in India. The evaporation is calculated from the formula

$$E = (1{\cdot}465 - 0{\cdot}0186\,B)\,(0{\cdot}44 + 0{\cdot}118\,W)\,\left(\frac{100}{h} - 1\right)e$$

where E is the mean daily evaporation in inches, B the barometric pressure at station level in inches, W the mean wind velocity of the day at 4 feet above ground in miles per hour, h the mean relative humidity and e the vapour pressure in inches of mercury. Monthly and annual evaporation charts have been drawn and discussed. The values of "rainfall *minus* evaporation" at the 80 stations have been calculated: these indicate the arid and the wet zones of the country. Finally, the importance of evaporation in salt-works and its influence on plant life have been discussed.

* * *

Earth Pressure Tables (Building Research Special Report No. 24. H. M. Stationery Office, Price 2*s.*)—These tables, published for the first time, give data necessary for calculating the

pressure exerted by granular materials on plane retaining walls of any batter, and are accompanied by a summary of the Revised Wedge Theory in so far as is required by the practical engineer when using the tables.

* * *

Johne's Disease of Cattle.—A useful and timely contribution on an important disease of cattle to which much attention has been given only of late appears as Bulletin 167,—New series, Dominion of Canada, Department of Agriculture. The nature, symptoms, post-mortem appearances, mode of the spread of the infection and methods of control of the Johne's disease are described in simple language so as to be easily understood by the live-stock owner. Much is not known yet about the disease but what little is known is brought out clearly in this small brochure. This disease—like tuberculosis—is as insidious as it is fatal, scouring and wasting being its chief signs. The infection is spread by direct contact with the affected animal or through contaminated pastures, ponds, etc. As there are no known methods, yet, of cure or preventive inoculation, the only measures advocated are destruction of the affected and in contact animals or, at least, strict isolation and thorough disinfection of the premises. As there is much reason to class this among the deficiency diseases properly balanced rations with the necessary vitamins and minerals should be particularly provided to all animals.

Certain additional information such as that sheep, goats and deer are also susceptible, though to a less extent than cattle, and that the disease is more often met with in low-lying and damp areas and also that the causal agency may be found in the rectal scrapings and in the milk of affected cows might have been included with advantage.

Much work has yet to be done to investigate the extent of the incidence of the disease and to discover diagnostic, therapeutic and prophylactic agents for combating it effectively. It is most satisfactory to note that the Imperial Council of Agricultural Research has taken up this question in earnest and has also awarded a grant for investigational work in Mysore.

It would be indeed most useful if this monograph could be translated into the various vernaculars in India and distributed among the owners of cattle.—S. D. A.

* * *

300th Anniversary of the Establishment of Chemical Industries in America.—The American Chemical Society will be celebrating at New York this Spring the tricentenary of the first serious American Chemical enterprise by John Winthrop, Jr. This will be a happy occasion for, few, even among chemists, have realised that the chemical production of America—measured in dollars or tons—is three times that of Germany, four times that of Great Britain and probably, half of the entire world's output. Modern American Chemical Industry is built solidly on research and holds a splendid record of achievement. It may be mentioned that a recent survey of the activities of the research and process development laboratories of the chemical industries revealed the fact that during the recent depression period, research was being continued without abatement. Many new processes have been developed for making products that could not be produced economically before and many new processes have been developed that have been designed to meet the needs of new and better living conditions.

During the celebration, a symposium on the "Economic, Social, Scientific and Political Foundations of the Chemical Industries" by leading industrialists, financiers and scientists has been organised. A very elaborate programme has been arranged with the assistance of the Merchants' Association, art and educational institutions and entertainment organisations of the New York City. Messrs. Lammot du Pont, E. M. Allen and George W. Merck, will co-operate with the Committee of the American Chemical Society headed by Prof. Arthur Hixson, in making the necessary arrangements.

* * *

Prof. William Whitehead Watts, F.R.S., the famous Geologist and author of the well-known '*Geology for Beginners*' which for 40 years has "provided the first introduction of the science to young Geologists in all the English-speaking World" has been elected President of the British Association for the Advancement of Science, 1935.

* * *

The Ramanujam Memorial Prize in Mathematics for 1933 which was offered by the Madras University for the best thesis based on original contributions submitted by an Indian (or one domiciled in India) on some definite branch of Mathematics, pure or applied, has been divided equally among (1) S. Chandrasekhar, M.A., for his thesis entitled "Polytropic Distribution"; (2) S. Chowla, Ph.D., for "The Theory of Dirichlet's L. Functions" and (3) D. D. Kosambi, for "Notes on the Mathematical Analysis of Space".

* * *

Element with Atomic Number 93.—Under the title *Bohemium—an obituary*. Max Speter, in a note published in *Science* (1934, **80**, 588) draws attention to the fact that the alleged element of atomic No. 93 and atomic weight 240, discovered by Odelen Koblic has been subjected to rigorous X-ray spectrographic study by Walter and Ida Noddack at Berlin. Negative results for an element of atomic No. 93 were obtained. Chemical tests show that the specimen consisted chiefly of tungsten, vanadium, etc. and tungsten was responsible for the observation that had led Koblic into his erroneous statement.

* * *

Irrigation Research in U.P., 1933-34.—The activities of the research section were confined to (1) the investigation of losses in water courses and in channels, (2) the study of the best means of lining channels and water courses, and (3) the design of distributary heads intended to exclude heavy silt. As it was of great importance to ascertain whether the lining of water courses was economically justified in tube-well projects, a very large number of experiments were undertaken to ascertain gul losses. The losses in small water courses varied with the depth of water. At present, the prevailing low prices make the lining of channels a doubtful economy. A number of fresh observations of losses in distributaries and minors showed that in general, the large channels gave smaller losses than the small ones, which fact lends colour to the view that the greater part of the losses occurs through the sides of channels. The greatest scope for lining is in small channels and water courses, and with this object several lining experiments were conducted.

A new form of lining, consisting of from one half inch to one inch thickness of cement mortar, reinforced with open weave hessian, was found useful. Tests into a number of silt-excluding heads constructed on different distributaries show that there are no means of complete silt exclusion; all that is possible is to reduce the amount. Experience on the Sarda Canal has shown that regime slopes are a function of the silt factor or type of silt transported, and that with a fine silt are associated flatter water surface slopes. Valuable silt distribution curves obtained from the Research Institute, Lahore, have shown that silt sampling is a most useful adjunct to the study of channel behaviour.

* * *

Annual Report of the Director, Research Institute, A. & U. Tibbi College, Delhi, for the year 1934.—This institute was started in March 1930 and is devoted to researches on the chemical constituents of indigenous medicinal plants. Valuable work on the alkaloids of *Holarrhena antidysentrica*, which has acquired immense medicinal interest through the pharmacological and therapeutic investigation of Col. Chopra and his co-workers as a cure for amœbic dysentery, has been carried out by the Director and his collaborators. The synthesis of the chief alkaloid of the plant Conessine has been achieved and this is a matter of considerable industrial significance. Among other researches carried out at the Institute, mention may be made of the work on the constitution of ajmaline and its subsidiary alkaloids, isolated from the *Rauwolfia serpentina*, Benth. These alkaloids have been successfully employed as a cure for violent insanity, chronic insomnia and chronic uterine and intestinal sluggishness. The work relating to the alkaloids of *Cassia absus*, Linn. also deserves mention.

In this report, the Director has stressed the need for expanding the Institute so as to include a Pharmacological Section. This is only appropriate as the work of the Institute is of a specialised character and calls for the co-operative efforts of organic chemists and pharmacologists. We hope that the authorities would be able to supply this long-felt want at an early date.

* * *

Indian Chemical Society—Eleventh Annual General Meeting, 1935.—At the annual meeting held on the 4th January 1935 with Dr. N. R. Dhar, the President of the Society, in the Chair, the following office-bearers were elected:—

President: Sir U. N. Brahmachari (1935-36); *Vice-President*: Sir Martin Onslow Forster (1935-37); *Honorary Secretary*: Prof. R. Ray (1935); *Honorary Treasurer*: Dr. Sudhamoy Ghosh (1935); *Honorary Auditors*: Mr. P. C. Nandi and Mr. J. P. Mookharjee (1935); *Ordinary Members*: Prof. R. N. Sen (Bengal) 1935-37; Dr. T. S. Wheeler (Bombay) 1935-37; Dr. P. C. Guha (S. India) 1935-37; Dr. K. R. Krishnaswami (S. India).

The President presented the Sir P. C. Ray 70th Birthday Commemoration Medal for 1933 to Mr. Susil Kumar Ray for his work on "Polyhalides" adjudged to be the best paper for the competition.

The President announced that Mr. Pulin Behari Sarkar has been recommended by the Board of Examiners for the J. M. Das Gupta Medal.

A Special Committee of the Council was formed in order to consider the advisability of instituting Associate membership, publishing news bulletin and abstracts of papers in the *Journal of the Society*.

* * *

We acknowledge, with thanks, the receipt of the latest number (Vol. VI, No. 4, Dec. 1934) of the *Quarterly Journal* published by the Geological, Mining and Metallurgical Society of India, Calcutta. The Society has to be congratulated on having successfully run the journal for these six years, thus providing a means of publication for several important papers on geological and allied subjects from workers in different parts of India. The general get-up of the journal is quite good. It strikes us, however, that the rates of subscription charged (Annual Rs. 16, Single copy Rs. 6) are a little too much, even after providing a wide margin for the high cost of scientific publication in India. We wish the journal a useful and prosperous career.

* * *

We have received three numbers of Volume I of *Marriage Hygiene*, a new Journal which is published from Bombay under the Editorship of Dr. A. P. Pillay. The journal is intended to diffuse sane and scientific ideas of sex problems and the use and technique of contraceptic methods among the educated Indians. Writing about the journal, Mrs. Edith How-Martin expresses as follows:—

"If this new journal of *Marriage Hygiene* can help to bring the light of scientific knowledge to bear upon and to overcome even some of the prejudices and social and religious taboos with which marriage is surrounded, it will make a notable contribution to human happiness."

Our sentiments are identical. The number for February 1935 contains articles written by the well-known writers like, Havelock Ellis, W. F. Geikie-Cobb, G. L. Gillin, R. R. Awati, Waldemar E. Coutts, Paul Popenoe, G. S. Ghurye, A. R. Kaufman and others.

We acknowledge with thanks the receipt of the following:—

"Actualites Scientifiques et Industrielles", Nos. 161, 163, 164, 165, 167, 170-175; 178-179; 181, 188, 194, 195, 197, 198, 205 and 208. (Hermann et cie, Paris).

"Journal of Agricultural Research," Vol. 49, No. 9, Nov. 1934; Index to Vol. 48, Jan. 1-July 15, 1934.

"Journal of Agriculture and Live-stock in India," Vol. 5, Pt. I, January 1935.

"The Journal of the Royal Society of Arts," Vol. 83, Nos. 4288-4291.

"Indian Journal of Agricultural Science," Vol. 4, Part VI, December 1934.

"Journal of the Annamalai University," Vol. IV, No. 1, January 1935.

"Biochemical Journal," Vol. 28, No. 6, Vol. 29, No. 1, 1935.

"American Journal of Botany," Vol. 22, No. 1, January 1935.

"The Journal of the Institute of Brewing," Vol. 41 (Vol. 32—New Series), No. 2, February 1935.

"Canadian Journal of Research," Vol. 12, No. 1, Jan. 1935: and Index to Vol. 11, July-Dec. 1934.

"Chemical Age," Vol. 32, Nos. 813-816.

"Berichte der Deutschen Chemischen Gesellschaft," Vol. 68, No. 2.

"The Journal of the Indian Chemical Society," Vol. 12, No. 1, January 1935.

"Experimental Station Record," Vol. 71, No. 6; Vol. 72, No. 1.
"Indian Forester," Vol. 61, No. 2, February 1935; No. 3, March 1935.
"Forschungen und Fortschritte," Vol. 12, Nos. 4-6.
"The Quarterly Journal of Geological, Mining and Metallurgical Society of India," Vol. 6, No. 4.
"Report on the 3rd Imperial Mycological Conference," 1934.
"Report of the 22nd Annual Conference of Educational Associations," held at the University College, London, 1934.
"Union of South Africa—Fisheries and Marine Biological Survey" Report No. 11, for the year ending December 1933.
"Report of the Fermentation Industries for 1934," by R. H. Hopkins and F. W. Norris.
"Second Report of the Royal Institute of Science, Bombay" (1926-1934).
"Indian Journal of Veterinary Science and Animal Husbandry," Vol. 4, No. 4, December 1934.
"Scripta Mathematica," Vol. 3, No. 1, January 1935.
"Nature," Vol. 135, Nos. 3404-3407.
"Natural History," January 1935 and February 1935.
"The Journal of Nutrition," Vol. 9, Nos. 1 and 2.
"Journal of the Osmania University College," Vol. 2, 1934.
"The Journal of Chemical Physics," Vol. 3, No. 2.
"Journal de Chimie Physique," Tome 31, No. 10; Tome 32, No. 1.
"The Indian Trade Journal," Vol. 116, Nos. 1494-1498.
"Indian Journal of Medical Research," Vol. 22, No. 3, January 1935.
"Marriage Hygiene," Vol. 1, Nos. 1-3, 1934-35.
"Department of Commercial Intelligence and Statistics, India,—Monthly Statistics of the Production of Certain Selected Industries of India." October 1934, No. 7 of 1934-35.
"Bulletin of the Patna Science College Philosophical Society," No. 5, January 1935.

Academies and Societies.

Indian Academy of Sciences.

(*Proceedings*, Vol. I, No. 8.)

SECTION A.

B. V. RAGHAVENDRA RAO: *Examination of Molecularly Scattered Light with a Fabry-Perot Etalon. Part II. Liquids: Toluene and Carbon Tetrachloride.*—It is found that the relative intensities of the central to the outer Doppler components is much greater for carbon tetrachloride than for toluene. The shift, reported by Cabannes, of the central Rayleigh line towards the red is unreal and is due to the fluctuations of temperature and pressure of the surroundings. T. S. SUBBARAYA: *On the Analysis of the Band Spectrum of Cadmium.*—The peculiar behaviour of the ground state, observed by the author for mercury, in having Δ F^{vv}'s which increase at first and then decrease, and in having a large anharmonic term, is found also in the case of cadmium. M. A. GOVINDA RAU AND B. N. NARAYANASWAMY: *Effect of Solvent in Dipole Moment Measurements.—Polarisation and Moment of Nitro-benzene.*—Six different solvents have been used, and the structure of the $-NO_2$ group is discussed. M. A. GOVINDA RAU: *Theory of the Solvent Effect in Dipole Moment Measurements.*—On the basis of the theory of Raman and Krishnan of anisotropic field constants prevailing in a liquid medium, a rigorous expression is derived for the polarisation of a solute in infinite dilution in a non-polar solvent, after eliminating the influence of the solvent. A. N. MELDRUM AND K. S. VAIDYANATHAN: *Synthesis of Substances Related to Cochinillic and Carminic Acids.*—The synthesis is effected through the condensation of chloral with 5-hydroxy-*m*-toluic acid. S. CHOWLA: *On Sums of Powers.* S. CHOWLA: *Some Infinite Series.* S. CHOWLA AND S. SASTRY: *On Sums of Powers.* P. K. SESHAN: *Chemical Studies on Coal.*—A study of a number of coals from the Indian and the American coalfields shows that cellulose is destroyed very much more rapidly than lignin at the earlier stages, and more slowly than lignin at the later stages of coalification. R. K. ASUNDI, C. M. BHASKER RAO AND R. SAMUEL: *On the Absorption Spectra of Some Organo-Metallic Compounds.*—Dimethyl, diethyl and diphenyl mercury, and diphenyl lead are among those studied in the vapour state. The results are discussed with Frank-Condon diagrams. K. NAGABHUSHANAM: *On the Form* $\sum_{r=1}^{n} p_r\, dq^r - H dt$. S. CHOWLA: *The Lattice Points in a Hypersphere.*

SECTION B.

S. S. PATWARDHAN: *On the Structure and Mechanism of the Gastric Mill in Decapoda. III—Structure of the Gastric Mill in Anomura.*—The seven types of Anomura examined contained a complex gastric mill. A brief account of the cordiac and the pyloric stomach and a comparative account of the principal ossicles of the gastric mill is given. S. S. PATWARDHAN: *On the Structure and Mechanism of the Gastric Mill in Decapoda. IV.—The Structure of the Gastric Mill in Reptantous Macrura.*—The suborder Macrura can be divided into two groups (*a*) Reptantous Macrura comprising crayfishes and lobsters, and (*b*) Natantous Macrura comprising prawns and shrimps. The former group is characterised by a universal presence of the gastric mill. BAHADUR SINGH AND T. N. SHIVAPURI: *The Gametophytes of* Neptunia oleracea, *Lour.* B. N. SINGH AND R. S. CHOUDHRI: *Induced Morphological, Physiological and Chemical Variations Following Seed-Exposure to X-Radiation in* Nicotiana tabacum.—As a result of the treatment with softer doses more vigorous and healthy crops can be produced. Variabilities in offspring are produced by X-radiation. T. EKAMBARAM AND RAMA RAO PANJE: *Contributions to Our Knowledge of* Balanophora. I.—The morphological relationships of the host with parasite as well as the manner of origin of the inflorescence has been dealt with.

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C. PRASAD AND J. B. JHA: *Potentiometric Estimation of Copper with Sodium Sulphide.* B. K. BANERJEE: *Studies in Acid Anhydrides. Action of Semicarbazides on Anhydrides of Dibasic Acids.* B. K. CHATTERJI AND B. L. VAISH: *A Note on the Determination of the Viscosities of Solutions by the Scarpa Method.* D. N. GHOSH: *On a New Type of Liquid-Liquid Junction.* EDWARD BARNES: *A Note on the Reduction of Selenium Dioxide by Carbon Monoxide.* PULIN BEHARI SARKAR: *On the Tensile Strength of Jute-fibre.* A. R. GHOSH AND B. C. GUHA: *Vitamin C in Indian Food-stuffs.* SALIMUZZAMAN SIDDIQUI AND RAFAT HUSSAIN SIDDIQUI: *The Alkaloids of* Rauwolfia Serpentina, *Benth. Part II. Studies in the Ajmaline Series.* H. M. MAPARA: *A Note on the Influence of Acidity of Agar on the Liesegang Rings of Lead Chromate and Lead Iodide.* PRIYADARANJAN RAY AND ANIL KUMAR MAZUMDAR: *Hydrazinates of Metallic Thiosulphates.* J. C. GHOSH AND SUKUMAR SEN: *On the Synthesis of Higher Paraffins from Water Gas. The Use of Promoters for Activating Iron-copper Catalyst.* S. M. ABDULLAH: *Addition of Compounds containing Reactive Methylene Group with Phenylvinylketone.*

Reviews.

HANDBUCH DER RADIOLOGIE. Herausgegeben von Prof. Dr. Eric Marx. Band 6: Quanten-mechanik der Matiere und Strahlung. Zweite Auflage der "Theorien der Radiologie." Teil 1: Atome and Elektronen. Pp. 466. Price 43-R.M. (Leipzig: Akademische Verlagsgesellschaft. m.b.H., 1934.)

The first part of this volume is devoted to the quantum mechanics of electrons and atoms and is divided into four chapters dealing respectively with the general theory, excitation and ionisation, electron theory of metals and nuclear physics. The third chapter is the shortest in the book covering about 50 pages and the last chapter is the largest with about 200 pages. While the scope of this Handbook is naturally more limited than the well-known *Handbuch der Physik* of Geiger and Scheel, it possesses all the advantages that a condensed account can give.

Chapter I:—This chapter contains all the essentials, from the point of view of a Physicist, of the theoretical portion of quantum mechanics. The knowledge of mathematics assumed on the part of the reader is not very great, such topics like the theory of groups, Hilbert space and matrices not being treated in any detail. A striking omission is an account of quantum statistics which is of the highest importance in special branches, specially the electron theory of metals. This chapter contains an article on mathematical preliminaries which is as devoted entirely to eigenfunctions and is as sweet as it is short. A very welcome feature of this article is the inclusion of Perron's theorem on the nodal points (lines or surfaces) of a wave function. The best part of the chapter is § 8 which gives a masterly exposition of Dirac's theory of the electron in the short space of twelve pages.

Chapter II:—This chapter contains a very full account of the experimental results relating to excitation and ionisation. To realise the vast amount of experimental work done in this branch one need only compare this chapter with the well-known book of Franck and Jordan on the excitation of quantum jumps by collision. One would however have wished to see in this chapter a little of the theory of the subject developed succinctly, at least the theory of collisions. Also the account given of thermal effects is rather inadequate. On pp. 223 and 225 the name of Saha is curiously written as "Megh nad Saha". The word "neutron" appears on p. 194, but a perusal of the article in question shows that the authors are using it in the sense of the neutral H-atom. It must however be pointed out that such a comprehensive treatment of the subject collected in one place is perhaps difficult to find elsewhere and this is specially true of photo-ionisation in the Röntgen region and excitation and ionisation of atoms in solid bodies.

Chapter III:—The theoretical aspect of the electron theory of metals can be formulated, thanks to the Fermi-Dirac statistics, in such a logical way that it is possible to present a connected account of the subject in a short compass. The distinguished author of this chapter, who is a recognised authority in the field, has made use of this fact in presenting what is easily one of the most readable accounts of the subject. After preliminary theoretical considerations, the Fermi-Dirac statistics is explained and direct applications are made to the passage of electrons through metallic surfaces, optical and X-rays properties of metals and to

conductors, semi-conductors and insulators. The theory of conductivity has one complete section devoted to it wherein all the related phenomena are briefly discussed. The complete omission of supra-conductivity in this chapter can certainly be justified on logical grounds since the extant electron theory of metals does not apply to the interaction of conduction electrons; but at least a mention of the theoretical difficulties and experimental results would have been very welcome indeed. The author departs from the usual practice in calling the Fermi-Dirac statistics merely Fermi-Statistics.

Chapter IV :—No branch of physics, not excluding theoretical quantum mechanics, has made and is making such rapid progress as nuclear physics. Experimental results follow one another with lightning rapidity; it thus happens that this chapter written in 1932 has no mention of the positron or the hydrogen isotope. A logical treatment of the subject is also out of question since even Dirac's relativistic theory of the electron is not adequate to treat problems of nuclear structure. Considering these handicaps, it must be said that the author's treatment of the problems of nuclear physics is really an achievement. The account is no mere catalogue of experimental results; quantum mechanics is freely applied in the discussion wherever possible and the difficulties presented clearly. In particular, the inadequacy of Dirac's theory is very well brought forth in the last section of the chapter. This judicious intermingling of experimental and theoretical results throughout the chapter makes it of the highest value to every worker in the subject. The neutron, however, is not given a theoretical background the reason being, perhaps, that Heisenberg's papers on the subject had not yet been published by the time this book went to press. Very full references are given to original papers without any unnecessary attempt at a complete bibliography. A curious error noticed is that in the *Namenverzeichnis*, p. 458 the name of Mott is given as Moté!

B. S. M.

HANDBUCH DER RADIOLOGY. Teil 2: Molekule, Pp. viii + 604. 56 gold marks.

This Handbook has been specially assigned for the quantum mechanics of a molecule. It contains authoritative articles on Band Spectra and Structure of Molecules by R. de L. Kronig, Electrical Properties of Molecules by P. Debye and H. Sack, Rayleigh Scattering and Raman Effect by G. Placzek, Molecular Theory of Magnetism by F. Bloch and Quantum Theory and Homopolar Binding by W. Heitler.

R. de L. Kronig has dealt first with the rotation vibration spectrum of a diatomic molecule, the vibration structure of the electron bands and the multiplicity of the electron states. He has also given the general treatment of a diatomic molecule and the symmetry properties of the energy levels. The explanation of the phenomenon of predissociation has been offered in a separate section. R. de L. Kronig's article is quite simple and clear though he has expressed his ideas in a concise manner.

P. Debye and H. Sack commencing with an account of the Clausius-Mosotti law and the Lorenz-Lorentz law, have presented a clear account of the theory of electrical polarisation and its dependence on temperature followed up by the idea of dipoles in molecules. They have devoted a section on dipole moment and chemical structure of molecules explaining how the vector conception of dipoles are helpful to determine the structure of molecules. Then follows a chapter on dispersion phenomena in gases and liquids. The last chapter in the article deals with the phenomena arising from the electrical asymmetry in molecules such as the Kerr Effect. They have also dealt with the relation between the Kerr constants and the structure of molecules.

G. Placzek has done a very good service to scientists in giving a fairly comprehensive account of the theory of the Rayleigh Scattering and the Raman Effect. First deriving the Rayleigh formula for the scattering of light, he has presented an account of Dirac's theory of the scattering of radiation with a general discussion of the scattering formula and a discussion of the same for freely oriented systems. Next he has presented the foundations of the polarisability theory whose conception explains the origin of the Raman lines. In particular, one needs to know the symmetry properties connected with a given polyatomic molecule to find which of the normal modes of vibration would be active in the Raman Effect and what would be the intensities of the Raman-radiations scattered by a molecule relative to the incident radiation. G. Placzek has therefore devoted a separate section for the symmetry properties and then he deals with the relation between those properties and

the selection rules for the Raman transitions. As some examples, he has given the applications of the theory to some well-known molecules and has suggested that the infrared spectrum and the Raman spectrum of gaseous benzene are of the highest interest. After these simple cases, he has also given a treatment of the splitting up of the Raman lines in CO_2, CS_2, CCl_4 and NH_3. Afterwards the theory of the rotational Raman lines has been dealt with reproducing two beautiful photographs of the rotational Raman spectra of nitrogen and ammonia, the first one taken by F. Rasetti and the other taken by E. Amaldi and himself. He closes his article with a section on empirical data connected with the calculation of the polarisability, etc. This article would have been more comprehensive and complete if he had devoted a separate section on the theory of the vibrations of various point systems under internal forces as this subject is very intimately connected with the explanation of the Raman spectra of molecules.

F. Bloch opens his article with the general facts of magnetism with an account of the thermodynamic relations and magneto-caloric effect. Then he gives the theory of the diamagnetism of atoms and molecules both from the classical and the quantum mechanical standpoints, and the diamagnetism of metals. In the section on paramagnetism, he gives the classical Langevin theory, the spin of the electron, the paramagnetism of atoms and molecules and that of the free electrons. In the section on ferromagnetism he deals with its characteristic properties, Weiss's hypothesis of molecular fields and Heisenberg's theory of ferromagnetism and the theory of ferromagnetism at high temperatures. He closes his article by sections on magnetic anisotropy, magnetostriction, "remanenz" and hysteresis.

W. Heitler has treated first with the nature of valence forces with an account of the interaction of two hydrogen atoms and a helium atom and a hydrogen atom. Then the relation between the Periodic classification and the Pauli Principle, the general theory of the interaction of atoms followed up by the details of the perturbation calculus and lastly the theory of the directed valence in polyatomic molecules have been treated in various sections.

Every article in this volume has been written with very great regard to high standard, clarity and conciseness. It is not too much to say that this volume will be exceedingly helpful both to the physicists and the physical chemists.

N. S. N.

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GENERAL ASTRONOMY. By Dr. H. Spencer Jones, F.R.S., Astronomer Royal. (Messrs. Edward Arnold & Co., Ltd., London, W.I.) Pp. 437. Price 12*s*. 6*d*.

The first edition of this interesting work appeared about twelve years ago and attracted considerable attention on account of the clear and lucid presentation it contained of a wide range of subjects in a manner suitable to the layman as well as to the serious student. In the years that have elapsed since then, the progress of astronomy has by no means been slow; the author has taken the opportunity in the second edition to incorporate the recent developments in the science and to completely rewrite some of the chapters that required more than ordinary revision and the result is, we have before us a well-written and comprehensive treatise which will indeed occupy a middle place between the large number of popular text-books and the strictly technical literature of the subject.

The work of revision has been thoroughly carried out and an attempt has been made not only to describe the extensive advances in our knowledge of the sidereal universe, but also to include in the earlier chapters additional matter dealing with the bodies of the solar system derived from recent researches. Some small errors in the former edition appear to have been rectified. A good deal of new material has been introduced in the section on stars which now occupies five chapters of the book. Some of the problems that have been receiving special attention during recent years such as rotation of stars, theory of novæ, galactic rotation and expansion of the Universe are treated in a clear and concise manner. There has been a considerable re-arrangement in the subject-matter according to the trend of modern ideas; the galactic and extra-galactic systems are dealt with in different chapters while the last chapter gives an account of the theories relating to the constitution of stars and their evolution.

A distinctive feature of this book is that mathematics has been carefully excluded; only the elementary formulæ required for the elucidation of the text are given so that the treatment may be intelligible to all classes of readers. In the limited space

available, the author has succeeded in giving a comprehensive survey of a large and growing subject and there can be little doubt, that in extent and completeness the book forms a compendium of great value. The style is readable and the explanations though brief on some points can be easily understood by the lay reader. To the serious student the book is valuable as providing an authoritative account of the principal features of modern astronomy. It may perhaps be suggested that a bibliography giving a list of references would be useful to those interested who desire to study the subject further.

The illustrations have been carefully selected and it is gratifying to note that with all these improvements the price has been substantially reduced. The treatise may be recommended as a text-book to be used by students taking a course of astronomy in Indian Universities.

T. P. B.

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THERMIONIC EMISSION. By Arnold L. Reiman, pp. xi + 324. (Chapman and Hall, London.) Price 21*s*.

It is doubtful if there is any single invention of the present century which is so useful and universal in application as the Thermionic Valve. It has entered every conceivable industry, it is a powerful tool in the hands of the experimental physicist, and is the very back-bone of Modern Broadcasting, which is providing such wonderful entertainment and education to the people throughout the world. Whether it is the simple triode or the pentode, or even the more complicated heptode that one meets occasionally, it is the simple phenomenon of thermionic emission that is responsible for its section. Ever since the momentous discovery by Thomas Edison in America, and its application to the construction of the first Thermionic Valve by Sir J. A. Flemming in England, it has formed the subject of close study by the practical physicist providing a great bulk of experimental data helpful to the theoretical physicist, particularly in the replacement of the classical, by the quantum statistics in the theory of electrons in metals, and also to the thermionic problem in wave-mechanical theory of the transmission of electrons through potential barriers.

There have been, no doubt, several books on the subject by Richardson and others, most of them fail to render a comprehensive account of the older and the more recent developments from the modern point of view, nor do they provide the many important data made available by new experimental methods and vacuum technique. The book under review fulfils this need. Mr. Rayner being among the research staff in the G. E. C. Laboratories, has first-hand information about the actual conditions of valve manufacture and has something interesting and important to say in the chapter dealing with the emission of electrons from contaminated cathodes, alloys and the oxides of Thorium and Tungsten. The book is roughly divided into four main sections; after a short introduction, survey of the whole field is given in the first chapter. In this is also discussed at some length the more important points like the work function, Richardson's emission formulæ, the Schottly effect, etc. The next few chapters are perhaps the very cream of the text. The admirably exhaustive discussion of the emission of electrons from clean metals, contaminated metals and oxide cathodes are really very stimulating, and will be of immense interest to the Radio Engineer. A chapter is also devoted to the discussion of the modern theory of electron emission and the emission of ions from electrolytes and from metals.

The inclusion of a few chapters on the experimental technique involved in certain operations would have proved to be most salutary to the interest of those who are practically minded. But even this omission is excusable since the slight digression would have involved a break in the continuity of thought so essential to the proper understanding of the subject.

Finally, the exhaustive bibliography appended at the end of each chapter is of incalculable value to the serious student in making available the original papers on the subject. The get-up of the book is of a high order, the diagrams and the illustrations are apt and help to elucidate the text and the book is sure to commend itself to the physicist and the Radio Engineer in whose shelf it will occupy the place of a handy, up-to-date book of reference.

C. C.

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THE MYSTERIES OF THE ATOM. By H. A. Wilson. (Chapman and Hall, Ltd., London, 1934.) Pp. x + 146. Price 10*s*. 6*d*.

It is one thing to write a text-book or a treatise on a subject meant for students

immediately interested in the particular subject, but quite a different thing to write an account of a supremely intricate and fundamental subject, as for instance, the structure of the atom, so as to make it understandable by readers with very little scientific training. Professor Wilson has set for himself the latter task and in the volume before us an attempt has been made to give a plain account of the modern notions concerning the ultimate particles constituting the universe.

The collapse of the classical laws governing the motion of particles as postulated by Newton, leading to a purely mechanical conception of the universe and the rise of the modern physics concerning the ultimate particles, resulting from the brilliant discoveries of J. J. Thomson, Rutherford, Rœntgen, Heisenberg, Schrœdinger, Dirac and others are treated in non-mathematical language, without entering into technical details. The experiments are described in simple language, the theory and calculations being consigned to the Appendices. Chapters IX and X dealing with the theories of relativity make heavy reading for the uninitiated, and may be omitted. The book fulfils a real want and the lay public who are interested in the modern developments but find in the many modern books only a mathematical treatment of the subject can profitably turn to this book where they will find matter which will amply repay study. The printing and get-up of the book are excellent.

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PHYSICO-CHEMICAL PRACTICAL EXERCISES. By William Norman Rae and Joseph Reilley. (Methuen & Co., Ltd., London, 1934.) Pp. iv + 276. Price 7*s.* 6*d.*

This book which has been brought out by the authors of the now famous work, *Physico-Chemical Methods*, covers the practical course for the B.Sc. Honours. It is comprehensive and thorough and the authors will undoubtedly win the gratitude of many appreciative students who will find in this book solutions for just those difficulties for which they consult the book. The exercises selected are those, which the authors have tried out and which in their experience have proved to be necessary for the students preparing for the Degree examinations. Theoretical principles have been given wherever necessary and the student will find this as also the worked examples very useful. We are confident that the book fulfils a real purpose and we are sure that students of chemical science will find it worth while to add this useful volume to their libraries.

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LES RADIOCOLLOIDES. By M. Haissinsky. (Hermann et Cie, Paris, 1934.) Pp. 25. 9 Francs.

In 1912 Paneth discovered that polonium, and radium E exhibited colloidal properties in the state of aqueous solutions either neutral, feebly acidic or ammoniacal. Thorium B, an isotope of lead, behaved likewise in ammoniacal solutions. The size of the particles in the solutions, calculated from the velocity of diffusion came out as 0·7$\mu\mu$ to 0·5$\mu\mu$, and thus explained the invisibility of the particles in an ultra-microscope. The real nature of these particles has, however, been a problem and two different views have been held, the one that they are radio-active compounds in true colloidal state, and the other that they are formed by the adsorption of their ions and molecules on the foreign colloids present in the solvent mediums.

M. Haissinsky, of the Institut du Radium, Paris, has sifted out in this monograph all the evidences so far advanced for either view, and has come to the conclusion that the properties of radio colloids are due to formation of true colloidal compounds, and that any foreign substances present play only a secondary rôle. There yet remains the difficulty that the observed solubilities of the hydroxides of lead and bismuth do not support the colloidal view. According to M. Haissinsky, however, the solubility measurements of very slightly soluble salts are of little significance, and cannot be directly applied to such solutions as the radio colloids.

M. A. G.

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AN INTRODUCTION TO PRACTICAL ORGANIC CHEMISTRY. By W. A. Waters. (Edward Arnold & Co., Ltd., London, 1934.) Pp. x + 92. Price 3*s.* 6*d.*

The book covers an elementary course of practical instruction in organic chemistry, useful for the B.Sc. students. It is divided into three parts, Part I dealing with the technique employed in organic chemistry starts from first principles and will prove to be of some use to all those who start on a course of organic chemistry—students of medical colleges, etc. The next part deals with preparative organic chemistry and reactions of groups and the last part with the

elementary principles of qualitative organic analysis.

There are several excellent books on practical organic chemistry and the reviewer finds hardly any purpose served in adding to their list a very elementary book which does not involve any original treatment of the subject. The student will, however, find in it some useful "tips", for his laboratory work.

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CHEMISTRY IN COMMERCE. Volumes I & II. Each Volume issued in eight weekly parts. General Editor: Edward Molloy. Vol. I, pp. 392. Vol. II, pp. 393–775 (George Newnes, Ltd., 1935.) Price 8*s.* per Volume.

One of the excerpts of the late Mr. S. M. Gluckstein was "A course of chemistry, it seems to me, is in itself an almost commercial education, encouraging as it does, patience, skill in observation,.....qualities, all of which are essential in modern commerce,"—words whose truth has been widely recognised, particularly in the post-war world.

In industrial works, chemists of all grades of equipment are met with—undergraduates, graduates and chemists with research qualifications. Besides these there are those who intend taking up chemistry as a profession; and all of them require to be informed how the works chemist utilises chemistry in controlling the processes and why the chemist has been considered a directing force in industry. The four volumes (to be issued in 32 weekly parts) which Messrs. Newnes have planned, attempt to provide this information, not merely by descriptive text, but also by action photographs.

The volumes are issued under the able editorship of Mr. Edward Molloy, and represent a co-operative effort, the various sections having been contributed by the chief chemists of some of the largest firms in England, who by virtue of their profession, are most qualified to describe how chemical principles are applied in actual practice.

The Editor has set himself an ambitious plan and judging from the volumes before us, a reasonable amount of success has been attained. The work is planned to show how the principles of chemistry find application in industrial processes and as it is made intensively practical, one who is interested in practising chemistry as a profession cannot fail to find in it a wealth of material which will be of immense utility to him. Notes on practical use of instruments like the spectrographs, microscopes, refractometers, polarimeters, viscosimeters, etc., are to be found in the volumes and also short discourses on the determination of moisture content; oxidation and reduction and some of their applications in industry; colour, its determination and measurement; Vitamin A; synthetic dyestuffs; etc. The work is profusely illustrated but one may doubt if all of them are necessary at all. To choose a few at random, figures No. 10 on p. 85, 7 on p. 162, 3 on p. 248, 4 and 5 on p. 287 and 8 on p. 373, do not appear to carry conviction. Fig. 6 on p. 106 and Fig. 14 on p. 110 do not appear to be different as also Figs. 5 on p. 105 and 13 on p. 109. The name of Alfred Nobel is not to be found at all in the first chapter on Founders of Chemistry. But these are all very minor omissions. Viewed as a whole the work contains a wealth of material and deserves to be read by every one interested in Chemistry.

The work must have a special appeal to India where a number of industries are rising and there is a crying need for vigorous chemical control of the processes. There is need for being armoured with every weapon of the modern industrial armoury, if India has to make for herself a place in the Industrial World. In this respect India has to learn a lesson from Japan where the Industrial Works not only employ chemists, but also stimulate the employment of chemists. Let us hope that those interested in the development of industries in India, will keep themselves alive to this fact; when they require information on the scientific requirements of industries, they can turn to these volumes, where, we trust, their requirements will be satisfied.

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THE PHYSIOLOGY OF HUMAN PERSPIRATION. By Yas Kuno, Professor of Physiology, Manchuria Medical College, Mukden. (London, J. and A. Churchill, Ltd., 1934.) Pp. 268 with 38 illustrations. Price 12*s.* 6*d.*

This is a concise but critical exposition of the present state of our knowledge concerning the physiology of human perspiration. The book which is the result of nearly ten years collaboration is rightly dedicated to the colleagues of the author. Much of the matter discussed in the book has been published originally in Japanese; and Prof. Kuno has surveyed the vast literature (both Japanese and Foreign) on the subject and formed a synthesis of his study and

experimental observation. The book comprises eleven Chapters. In the first chapter the morphology and innervation of the sweat glands are described. Chapter II contains a clear account of the methods which Prof. Kuno and his collaborators have employed in the laboratory for the measurement of "perspiration" and a simple but acknowledged yet to be imperfect portable apparatus for use by the Physicians is also described. Chapter III deals with a discussion of the descriptive terms employed and of various factors influencing "sensible" and "insensible" perspiration. Chapter IV contains an account of thermal sweating, a subject on which there appears to be no previous description of authentic nature. This chapter is of considerable importance. In the fifth chapter an interesting account of the features of mental sweating with special reference to the causes of such sweating is given. Further the special characteristics of the perspiration of the palm and the sole on the one hand and the other of the axilla are described. In the sixth chapter the effect of mental stress on the perspiration at varying temperatures is discussed and the question concerning the intrinsic causes of variation in the "palmar sweating" and suppression of general sweating is declared to be obscure at present. The results of a systematic investigation of the features of the sweating due to muscular exercise are embodied in chapter VII and the conclusion that "no process other than the effort necessary for performing muscular exercise can therefore be considered as the cause of this sweating" is reached. The asphyxial conditions during very strenuous muscular exercise would however be an additional cause of the sweating on the general surface of the body. In chapter VIII the physiological necessity for supplying in time water and sodium chloride lost by perspiration is described. The importance of adding minute quantities of salt to the water that workers in over-heated places drink is discussed. Chapter IX is concerned with an account of variations in the ability to perspire due to alterations in the surrounding temperature and to abnormal conditions of the body itself. Individual variations in the ability to perspire with reference to mountain climbing, forced marches of soldiers, etc., are observed. Further the possibility of "training of the sweat glands" is noted. The influence exerted by the osmotic pressure of blood in regulating the sweating process is impressively dealt with, and the injection of hypertonic salt solution has been suggested as worthy of trial in cases of hyperhidrosis. In chapter X a systematic account of the processes involved in the production and inhibition of sweating is offered. Besides noting the variations in the excitability of the individual sweat glands and the periodic discharge of sweat from individual glands, the oxygen consumption of actively secreting glands is dealt with. Chapter XI details the physiological significance of sweating. According to the author, in the human individual the sweat gland of the general body surface plays a very important rôle in temperature regulation, whilst those on the sole and the palm assist by their perpetual secretion in protecting the skin and by sweating facilitate physical work. The sweat from the human axilla disseminates the axillary scent which seems to have a sexual significance. Further, the function of the sweat glands in the elimination of lactic acid during muscular exercise, and the consequent regulation of the H-ion concentration of the blood is discussed. There is an extensive and useful bibliography, and the book is well indexed. The general get-up of the volume is excellent like all other books published by J. and A. Churchill Ltd. The volume deserves a place on the book shelf of every advanced student, teacher and researcher engaged in the study of Physiology.

A. S. R.

Errata.

* 1935, **3**, 347-348 (*Cf.* The Theory of Liquids).

(1) In every instance *for* the suffix '$m\mu$' *read* (*m.p.*)

(2) In equations (4), (6) and (8) *for* 'γ' *read* 'ν'

(3) In equation (6) and (7) *for* 'M' *read* 'm'.

(4) Foot-note 2, *for* 477, *read* 497.

(5) In equation (10) *for* $\sigma \frac{m-1}{m.\mu}$ *read* $(\sigma_{m.p})^{\frac{m-1}{m.\mu}}$

* Through oversight the proofs were not sent to the author.

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VOLTA